POWER PLANT ENGINEERING

Established Over 35 Years

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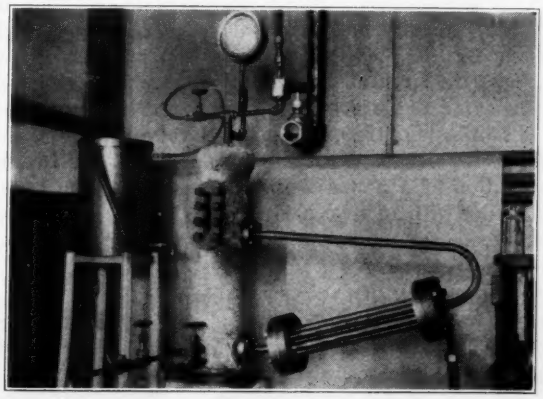


Modern High-Pressure Boiler of 0.219 Hp. Capacity

SHE'S LITTLE but—oh boy! how she can turn out the steam. The surface of the seven boiler tubes is only 2.19 sq. ft.; headers, tubes, drum and accessories have been built for 1200 lb. pressure and have already been operated at 600 lb. The furnace built around the heating element shown here is fired by five gas burners and the unit has been operated at about 800 per cent of rating figured on the basis of its heating surface.

The vertical drum is provided with two flat-type high-pressure water glasses, there is a safety valve consisting of a 1/64-in. plate that will rupture if pressure goes above a safe limit and the boiler feed pump is a constant feeding chemical proportioning pump. All she lacks is a whistle.

This unusual installation has recently been made in the laboratories of National Aluminate Corp. for making determinations of carryover and action of water and steam under operating conditions for various types of boiler feedwater. These determinations are made to ascertain what sort of treatment should be applied to a particular feedwater.

The water is boiled, the steam passes to the condenser on the left and the condensate is analyzed. If priming or foaming occur, they can be observed through the gage glasses. The relation of steam releasing surface to water heating surface has been made practically the same as that in most standard types of vertical bent-tube boilers.

You are not interested in babies? Well, then, turn to page 348 and see if you like grownups better. Boilers for 1200 lb. pressure are getting their share of attention. And if you don't like those, turn to page 354 and see the man sized ones that are helping Henry Ford turn out Lady Beths, the grown up Lizzie of yesterday.

More Steam for More Beech-Nut Tomato Catsup

LOW HEADROOM 437-HP. BOILER FIRED BY PULVERIZED COAL, INSTALLED IN RESTRICTED SPACE IN EXISTING BOILER HOUSE, DOUBLES STEAM SUPPLY FOR ROCHESTER PLANT OF BEECH-NUT PACKING CO.

WHEN THE PROCESS STEAM demands of an industrial plant increase 100 per cent and the existing boilers are already operating at maximum capacity, considerable skill and ingenuity must be displayed by the plant engineering force to solve the problem at a reasonable cost. This was the situation presented to the engineering department of the Beech-Nut Packing Co. at Rochester, N. Y., in April, 1929. As a result of its studies, the engineering department completed in August, 1929, the installation of a new 437-hp. low-headroom type water tube boiler with an air-cooled furnace fired by pulverized coal, erected in the boiler house of the Rochester plant in the space formerly occupied by two horizontal return tubular boilers, without any alteration in the existing building.

This unit has operated at 250 per cent rating for prolonged periods, has met the increased steam demand, has shown an efficiency of boiler and furnace of 76.5 per cent at 195 per cent of rating from the daily records and, according to the plant engineers, has fulfilled all expectations. The cost has been low and the operation satisfactory.

This unit makes steam for heating and process work only; all electric power is purchased from the local public utility company.

With the foregoing general impression in mind, it will be of interest to consider the principal reasons governing the selection of this equipment, the results of operation and the details of the equipment itself.

FACTORS INFLUENCING DESIGN

The original boiler plant at the Rochester factory consisted of four 150-hp. horizontal return tubular boilers fired by side-feed V-type stokers. As noted above, increased manufacturing capacity demanded 100 per cent increase of steam generation and after considerable study the low-headroom 437-hp. boiler fired by a unit pulverizer was decided upon. Taking account of the furnace volume, fans, breeching and duct work, this equipment could be installed in the space occupied by two of the existing boilers.

It was necessary to keep the two remaining boilers in service to care for normal steam demand. The new equipment had to be in service to generate steam required for process canning of the ripening crop of tomatoes. By skillful arrangement of the equipment in a comparatively small space, it was possible to avoid any alteration in the building, thus eliminating considerable expense. As an illustration of this careful arrangement, the main boiler drum manhole comes about level with the middle of the roof trusses and is entered by going through the transfer space between two truss members. There was only 20 ft. 4 in. headroom available between floor and bottom chord of truss in which to install the

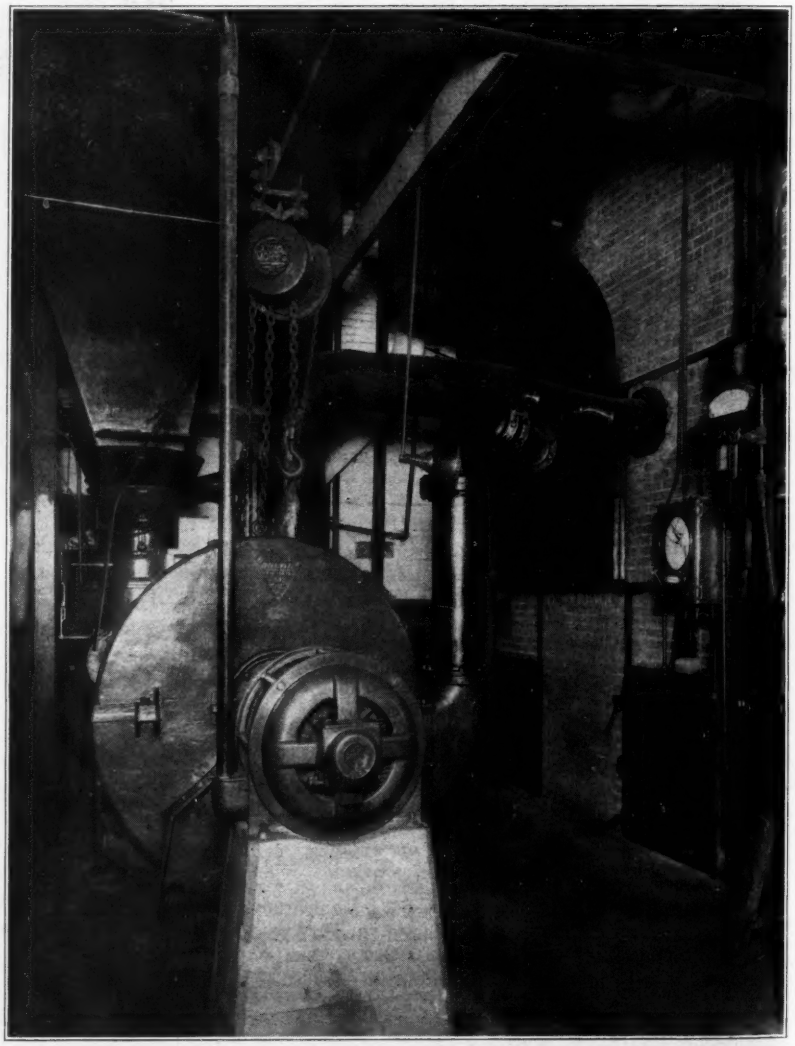


FIG. 1. FRONT OF NEW 437-HP. BOILER SHOWING PULVERIZER, BURNER, SECONDARY AIR DUCT, GAS DUCT FROM FURNACE TO PULVERIZER AND INSTRUMENTS FOR OPERATING UNIT

equipment. The induced and forced draft fans had to be installed over the boiler as shown. The only change necessary in existing construction was the relocation of a portion of the main steam header.

It is evident, therefore, that the installation of the equipment was not made under ideal conditions. Under such conditions, the work of the plant engineering force in maintaining service from the old boilers and getting the new equipment installed and in operation only 5 mos. after the problem was presented to it, merits approbation.

In the preliminary investigations to to what equipment would best solve the problem of doubling steam capacity, considerable study was made of the possibilities of the side-dump underfeed stoker. The nature of the load, however, the problem of ash removal and the calculated overall efficiency at high ratings were factors that militated against its use.

The preliminary studies showed that the steam demand could be met with a multiple-retort, underfeed, rear-dump, continuous ash discharge stoker or with pulverized coal. Cost of ash removal from this stoker, however, was considered prohibitive in this particular case. After evaluating all the factors, a suitable pulverized coal installation proved to be the best solution of the problem.

Various makes and types of boilers were studied and the type H design for low headroom as shown in Fig. 2 was finally adopted. It is stated that this is the only type H boiler at present fired by pulverized coal.

Use of an induced draft fan was necessary to permit the use of the existing stack and to handle flue gas when the plant is generating 1800 boiler horsepower. For proper control of secondary air to the pulverized coal burner, a forced draft fan was employed. Gas is drawn from the furnace for drying the coal in the mill as will be explained in detail later.

Results of Operation

The new boiler was started and put on the line Aug. 28, 1929, and remained in service 640 hr. During this period it was operated at outputs ranging between 40 per cent and 250 per cent of rating. It was not necessary to take the boiler off the line on account of mechanical difficulties with any part of the equipment. No ash, was removed from the furnace bottom until after six weeks of operation. The boiler was then taken off the line during a week end, the ash was removed, in 6 hr., and the unit was put back in service for the remainder of the canning season.

During operation, the water level in the gage glass on the water column remained constant. This was under the control of an automatic feedwater regulator; there was no noticeable variation in water level as the circulation in the boiler is entirely satisfactory. Under the wide range of load as shown by the charts, the pulverized coal equipment proved flexible and required a minimum of attention on the part of the operator. Coal fired to the pulverizer and control damper for secondary air supply to the burner are regulated by hand. Furnace draft is also controlled by a hand damper and by a variable speed motor on the induced draft fan. This control of secondary air has proved extremely flexible in controlling the CO_2. Instruments are all on the boiler front together with induced draft fan motor controls; thus the operator has all facilities for control in a compact group.

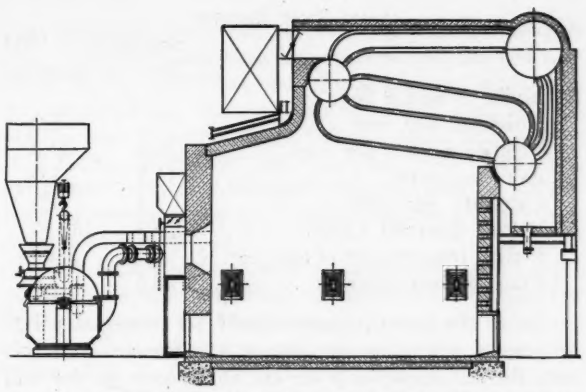


FIG. 2. CROSS-SECTION OF BOILER SETTING, SHOWING LOW HEADROOM BOILER

This boiler installation has been operating for 18 mo. and has fulfilled all guarantees and expectations. Maintenance of boiler and setting has been negligible. The pulverizer grinding segments have been replaced with a low maintenance cost of 4.67 cents a ton of pulverized coal.

To sum up, the unit pulverizer fitted well into the available space, cost about the same as a multiple retort stoker for this service, requires a little more power and is easily controlled with fluctuating loads. Increase in power consumed is counterbalanced by lower cost of pulverizer coal and ease of operation.

A typical example of performance is shown by the plant records of September 11, 1930, obtained under normal operating conditions with fluctuating load. This performance is as follows:

Operating Data from Plant Records

1—Total heating surface of boiler	4370 sq. ft.
2—Furnace volume	3300 cu. ft.
3—Date	9-10-30
4—Duration	12 hr.
5—Kind and size of coal	Sykesville Pulverizer Coal
6—Steam pressure gage	110 lb.
7—Temperature of feed entering boiler	212 deg. F.
8—Percentage of moisture in steam	———
9—Percentage of moisture in coal	1.2
10—Coal consumed per hour	2766.0 lb.
Dry coal consumed per hour	2732.8 lb.
11—Equivalent evaporation per hr. from and at 212 deg. F	29,404.9 lb.
12—Boiler horsepower developed per hour	852.3
13—Percentage of rated capacity developed	195
14—Equivalent evaporation from and at 212 deg. F. per lb. of coal as fired	10.63
15—Equivalent evaporation from and at 212 deg. F. per lb. of dry coal	10.76
16—Average CO_2, per cent	13.0
17—Calorific value of 1 lb. of dry coal by calorimeter	13,675 B.t.u. lb.
18—Average flue gas temperature	580 deg. F.
19—Average furnace draft, in water	0.15
20—Efficiency of boiler and furnace, per cent	76.5

COAL TEST REPORT

	September 2, 1930 Dry	As Received
Sykesville B and S 9586		
Moisture, per cent	....	1.2
Volatile matter, per cent	30.3	30.0
Ash, per cent	11.1	11.0
Sulphur., per cent	1.4	1.3
British Thermal Units	13,765	13,585
Fusing temperature of ash, deg. F.	....	2800+
Fixed carbon, per cent	58.6	57.8

As to the new equipment itself, its principal points of interest are the boiler proper, the furnace construction, the air supply and the use of furnace gas for mill drying. Complete data on the equipment are given in the attached list.

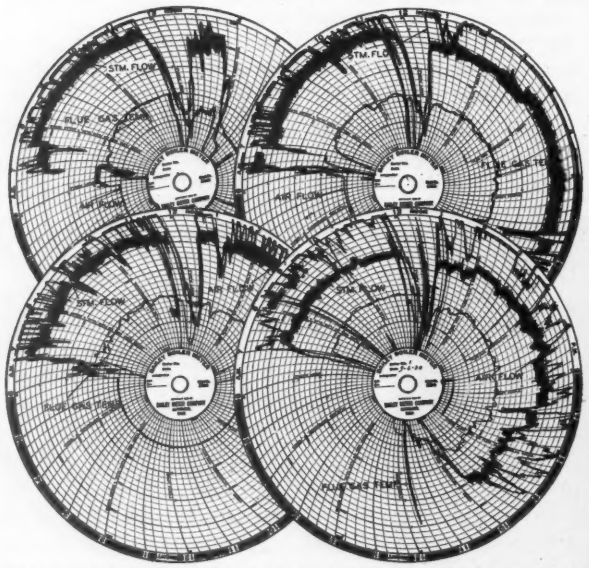


FIG. 3. FOUR TYPICAL BOILER METER CHARTS THAT SHOW THE WIDE VARIATIONS IN LOAD THAT THE EQUIPMENT MUST HANDLE

BOILER AND FURNACE DETAILS

The boiler, designed for 180 lb. steam pressure but operated at 125 lb., is of the low headroom type, Fig. 2. It has 4370 sq. ft. of heating surface, the tubes arranged as shown. The boiler company's standard baffling, not shown by Fig. 2, was used. No superheater is installed, steam temperature is that of saturation, about 353 deg. At the rear of the setting is a flyash hopper from which ash deposited here can be discharged to an industrial car below.

Flue gas passes out of the boiler at the front end of the boiler; that is, the end towards the burner. Here the induced draft fan is set, immediately over the arch as shown in Figs. 2 and 4; this fan and the variable speed motor that drives it are set on steel beams so that the motor is almost over the green coal hopper feeding the pulverizer. This fan, as noted above, discharges to the existing chimney and has sufficient capacity to supply the required draft when the entire plant is operating—the new boiler and the two old ones that still remain in the boiler house.

The furnace has a capacity of 3300 cu. ft. and is designed for an average heat release of about 15,000 B.t.u. per cu. ft. per hr. It has a flat bottom and in front and rear walls are large cleanout doors, permitting easy access for ash removal. Front wall of the furnace, through which the burner fires, is of solid refractory construction. Side and rear walls are air-cooled refractory construction.

Air passes up through these walls to ducts at the top of the walls, from which a small secondary air or forced draft fan sends it to the pulverized coal burner through the curved duct shown in Figs. 1 and 4. Capacity of this secondary air fan is about 16,000 c.f.m. at 4 in. H_2O static pressure. In passing through the hollow walls, the secondary air is heated to about 130 deg. F.

Instead of using heated air for drying coal in pulverizing mill, gas from the furnace is employed. A duct running from the right-hand front wall of the furnace just above the burner level, Figs. 1 and 2, carries this furnace gas to the pulverizing mill. The furnace gas is tempered with room air by means of a damper so that the gas and air for drying coal enter the mill at about 400 deg. F. for coal having high total moisture content. Lower temperature gas and air are used for coal having less moisture. The mill is a standard attrition type pulverizer with capacity of 4000 lb. of coal an hour.

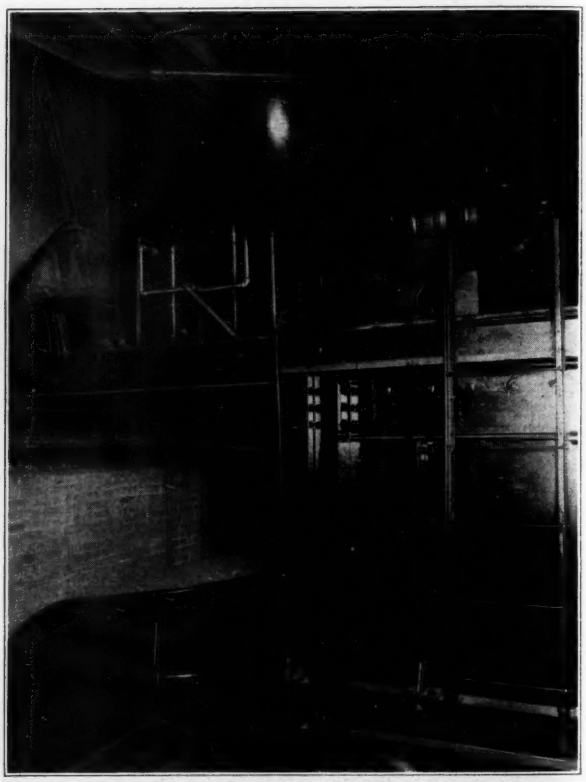


FIG. 4. INDUCED DRAFT FAN AND MOTOR OVER BOILER FRONT. CURVED DUCT BELOW RUNS FROM SECONDARY AIR FAN TO BURNER

Only one flare type burner, of 4000 lb. of coal an hour capacity, is used to fire this furnace. As the lowest load this burner will carry is about 200 hp. it is planned to install another smaller burner in the front wall to carry loads less than 200 hp.

Coal is weighed in barrows outside the plant, then dumped into the hopper of a bucket-elevator that fills the green-coal hopper over the pulverizer, Fig. 1. The pulverizer feeder and magnetic separator are easily accessible to the boiler-operator for adjustment and observation.

When the above equipment was installed, a new 68,600-g.p.h. water softener was also put in to serve the entire plant. For feeding the new boiler, two duplex steam pumps were supplied, with pump governors to control them and a thermostatic differential type feedwater level regulator to govern boiler water level.

A new switchboard was also installed in a small extension to the power house to handle the increased electric power load of the boiler house and factory. Power at 208 v. is distributed from this board over a 4-wire, 3-phase 60-cycle distribution system in the factory.

It is evident that although the new boiler unit of the Beech-Nut Packing Co. at Rochester is comparatively small in size, it illustrates one satisfactory solution of the vexing problem common to many growing industries, that of increased steam supply at reasonable cost to keep pace with growing factory production.

PRINCIPAL NEW EQUIPMENT AT ROCHESTER PLANT OF BEECH-NUT PACKING CO.

BOILER ..... Babcock & Wilcox Co.
437 hp., Type H, Stirling, for low headroom, 3¼ in. diameter tubes; 48 in. steam drum.
Steam pressure 180 lb. sq. in.

FURNACE ..... Wm. Summerhays Sons, Inc., Rochester, N. Y.
Furnace volume, 3300 cu. ft.; front wall refractory.
Side walls, air-cooled
Rear wall, air-cooled } Bigelow-Liptak Corp.
Arch

PULVERIZED FUEL EQUIPMENT ..... Riley Stoker Co.
1 Unit pulverizer, Riley Atrita, size No. 4. Pulverizer capacity, 4000 lb. per hr.
1 Riley burner and nozzles complete with dampers for secondary air.
1 Magnetic separator integral with feeder.
Separator provided with disconnecting switch, and a device to indicate whether separator coils are magnetized.
2-t Morris hand-operated hoist for handling pulverizer parts.
Pulverizer drive—1 50-hp. motor, 1200 r.p.m., 220 v., 3-phase, 60 cycle, squirrel cage—General Electric Co.

SECONDARY AIR ..... Buffalo Forge Co.
No. 6 Turbo Conoidal Fan, direct connected to a 20-hp. General Electric Motor.

PERFORMANCE GUARANTEES

Boiler Rating Per Cent	Flue Gas Deg. F. Temperature	Combined Efficiency Per Cent
100	485	80
150	545	79
200	600	76
230	640	74

COAL AND ASH HANDLING ..... Link-Belt Co.
Coal is weighed and bucket elevator elevates coal to a 5-t. bin whence it flows by gravity to the pulverizer feeder.

FEEDWATER PUMPS ..... Worthington Pump & Mach'y Corp.
2 Duplex Steam Pumps, with Copes pump regulators.

INSTRUMENTS
Bailey Meter recording and integrating steam flow, air flow, draft and flue gas temp. ..... Bailey Meter Co.
Ranarex CO_2 Recorder ..... Permutit Co.

WATER SOFTENERS ..... Paige & Jones Chemical Co.
Capacity 68,600 gal. an hour.

INDUCED DRAFT FAN ..... Buffalo Forge Co.
No. 8½ Duplex fan direct connected to a 50-hp. G.E. variable speed motor.

SWITCHBOARD furnished by General Electric Co., Ebony Asbestos panels; 1 air circuit breaker, 2000 amp. capacity; 1 air circuit breaker, 1200 amp. capacity; watt-hour meter, etc.

SOOT BLOWERS ..... Diamond Power Specialty Co.
BREECHINGS ..... Buffalo Forge Co.
DUCT WORK ..... Fleisch & Schmitt Co.
BLOWOFF VALVES ..... Yarnall-Waring Co.
NON-RETURN VALVE ..... Crane Co.
SAFETY VALVES ..... Consolidated Ashcroft Hancock Co., Inc.
BLOWOFF TANK ..... Barr & Creelman Co.
FEEDWATER REGULATOR (Copes) ..... Northern Equipment Co.
WATER COLUMN ..... Kitts Mfg. Co.
STEAM PRESSURE GAGES ..... Consolidated Ashcroft Hancock Co., Inc.

When a particular plant cannot justify itself in making its own power and for various reasons cannot buy process steam or finds it can make steam cheaper than it can buy it, the solution of the problem of increasing steam production follows a line different from that involving generation of its own power. In each case, of course, data must be compiled and the problem solved as an individual one. Some of the variables to be considered are: price of coal and labor, costs of generation and distribution of process steam and power, load factor, investment and operating costs as affected by present size and expected growth, relative advantages of various types and arrangements of power plant equipment and so on.

Such factors as these were all considered by the engineering department and management of the Beech-Nut Packing Co. in the design of the new unit described above. This design was carried out under the supervision of L. A. Cook, mechanical engineer for the company, who also had charge of its erection and supervises its operation. We are indebted to Mr. Cook for his cordial coöperation in enabling us to visit the plant and his assistance in securing the data and illustrations used in this article.

Quick-Freezing of Pipes for Repairs

NEW CONNECTIONS often have to be put in and repairs made to pipe lines with a minimum interruption of service in plumbing practice. Often no convenient shut-off valves are in these lines and it has been necessary in the past to resort to freezing a plug of ice in the line before it can be opened. When ice and salt are used for this purpose, the freezing is slow and not always safe. Recently a fast and handy method of freezing pipes for shut-off has been developed through the use of solid carbon dioxide, most widely known under the trade-mark "Dry-ice."

"Dry-ice," at 109.6 deg. below zero, is so cold that large water mains can be easily and quickly frozen, and thus completely blocked, through its use, even when under ordinary water pressure. Twenty minutes is long enough to freeze a two-inch water line in service. In the same way, lines carrying many other liquids, including practically all water solutions, the common acids and most of the other liquids usually handled in industrial plants may be temporarily blocked by freezing. There are, of course, exceptions. Alcohol, ether, acetone and a few other solvents cannot be frozen in this way.

The method consists in packing a quantity of "Dry-ice," either cut or broken into pieces of convenient size, around the pipe on the pressure side of the proposed break. After the work has been done, only a short time is required to allow the pipe to thaw and resume service.

The method can be applied to lines while in service and the shut-off is practically no longer than is required to do the job itself. In thorough tests of the method, no pipe has been burst by freezing in this way in plumbing practice on wrought and cast iron pipe containing water. The general distribution of "Dry-ice" throughout the United States makes this material easily available everywhere.

The quantity of "Dry-ice" required for this purpose naturally varies rather widely depending on the pipe size, temperature, time and other obvious factors, but in general the cost of the method has been found to be very low when time of shut-down is an important item, as it usually is.

Comparison of Natural Gas Boiler Fuels

DETAILS OF THE METHOD OF CONVERTING VOLUMETRIC TO GRAVIMETRIC ANALYSIS FOR USE IN COMBUSTION PROBLEMS. BY PALMER B. PLACE*

ANALYSIS AND CHARACTERISTICS of manufactured and natural gas fuels are usually given in terms of cubic feet at a given temperature and pressure. Since heat balance and combustion calculations are best made on a weight basis, it is desirable to convert the volumetric analysis into a gravimetric analysis. This is especially true when comparing gaseous fuels with solid

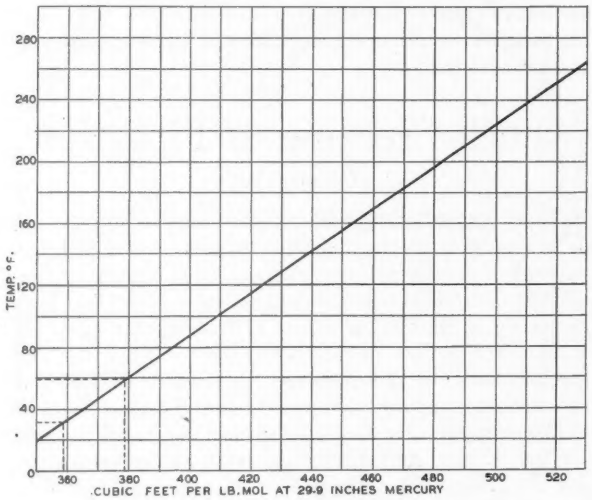


FIG. 1. MOLECULAR VOLUME AS A FUNCTION OF THE TEMPERATURE

fuels. The mol system offers the most convenient method of conversion and requires only a knowlege of the following established principles.

1. A mol is a molecular weight of any substance. It is expressed in any unit of weight but unless otherwise designated, is understood to be in pounds. Thus, a mol of methane is 16 lb. of methane.

2. A mol of any gas under standard conditions of 32 deg. F. and 14.7 lb. pressure will occupy 359 cu. ft., or expressed in another manner, 359 cu. ft. of a gas under standard conditions, will weigh a molecular weight in pounds of that gas. Thus, 16 lb. of methane under standard conditions will occupy 359 cu. ft.

3. Per cent by volume is numerically the same as per cent by mol. This relationship allows a direct change from a volume to a weight basis. For example, air has a molecular weight of 28.84 and contains 20.9 per cent by volume of oxygen. Therefore a mol of air will contain 0.209 mol of oxygen and since a mol of oxygen is 32 lb., a mol of air (28.84 lb.) contains $0.209 \times 32 = 6.69$ lb. of oxygen, which is 23.2 per cent by weight.

4. Gas volumes are proportional to the absolute temperature and inversely proportional to the absolute pressure. Thus 359 cu. ft. under standard conditions of 32 deg. F. and 14.7 lb. pressure expands to 379 cu. ft. at 60 deg. F. and the same pressure. Expressing the volume in cubic feet, the pressure in pounds per square inch absolute and the temperature in degrees absolute (460 + deg. F.), the relationship is fully expressed by the following equation: $P_1V_1T_2 = P_2V_2T_1$ or $(14.7)(359) \div 492 = P_2V_2 \div T_2 = 10.726$. The volume occupied by a molecular weight in pounds of a gas is called the molecular volume and the variation in the molecular volume due to changes in temperature at a constant pressure of 14.7 lb. is shown in Fig. 1. Thus,

*Combustion Engineering Corp., New York, N. Y.

TABLE I. VOLUMETRIC ANALYSIS, HEAT VALUE, MOLECULAR WEIGHT, AND DENSITY OF TYPICAL NATURAL GAS SAMPLES

Sample No.	Methane CH_4	Ethane C_2H_6	Propane C_3H_8	Carbon Dioxide CO_2	Nitrogen N_2	B.t.u. per cu. ft. 60° F.	Molecular weight	Density lb/cu. ft. 60° F.
1.	98.5	...	...	...	1.5	1002	16.18	.0427
2.	91.3	4.5	...	0.8	3.4	999	17.26	.0455
3.	84.7	9.4	4.3	...	1.6	1126	18.71	.0494
4.	80.5	18.5	...	...	1.0	1140	18.71	.0494
5.	73.2	25.6	...	...	1.2	1188	19.73	.0521
6.	77.5	16.0	...	6.5	...	1061	20.06	.0529
7.	50.6	10.9	...	0.1	38.4	702	22.16	.0585
8.	59.1	14.5	...	25.1	1.3	849	25.21	.0665
9.	32.2	67.0	...	...	0.7	1482	25.47	.0672
10.	...	31.8	67.7	...	0.5	2269	39.44	.1038

TABLE II. MOLECULAR WEIGHT, DENSITY, AND COMPOSITION OF THE USUAL CONSTITUENTS OF NATURAL GAS FUELS

Constituent	Formula	Molecular Weight	Density 60° F.	Per cent by Weight Hydrogen	Carbon	Oxygen	Nitrogen
Methane	CH_4	16	.0422	25.00	75.00	.....	.....
Ethane	C_2H_6	30	.0792	20.00	80.00	.....	.....
Propane	C_3H_8	44	.1161	18.18	81.82	.....	.....
Carbon dioxide	CO_2	44	.1161	.....	27.27	72.73	.....
Water vapor	H_2O	18	.0475	11.11	.....	88.89	.....
Nitrogen	N_2	28	.0739	.....	.....	.....	100.00
Hydrogen*	H_2	2	.00528	100.00	.....	.....	.....
Carbon*	C	12	....	.....	100.00	.....	.....
Oxygen*	O_2	32	.0844	.....	.....	100.00	.....

*Do not usually occur in the free state.

TABLE III. CONVERSION OF VOLUMETRIC TO GRAVIMETRIC ANALYSIS

Sample No.	Methane CH_4	Ethane C_2H_6	Propane C_3H_8	Carbon Dioxide CO_2	Nitrogen N_2	Molecular Weight of Mixture
1. Per cent by vol.	98.5	....	....	....	1.5	
lb/lb. mol. mix.	15.76	....	....	....	0.42	16.18
Per cent by wt.	97.4	....	....	....	2.6	
2. Per cent by vol.	91.3	4.5	....	0.8	3.4	
lb/lb. mol. mix.	14.61	1.35	....	0.35	0.95	17.26
Per cent by wt.	84.7	7.8	....	2.0	5.5	
3. Per cent by vol.	84.7	9.4	4.3	....	1.6	
lb/lb. mol. mix.	13.55	2.82	1.89	....	0.45	18.71
Per cent by wt.	72.4	15.1	10.1	....	2.4	
4. Per cent by vol.	80.5	18.5	....	....	1.0	
lb/lb. mol. mix.	12.88	5.55	....	....	0.28	18.71
Per cent by wt.	68.8	29.7	....	....	1.5	
5. Per cent by vol.	73.2	25.6	....	....	1.2	
lb/lb. mol. mix.	11.71	7.68	....	....	0.34	19.73
Per cent by wt.	59.4	38.9	....	....	1.7	
6. Per cent by vol.	77.5	16.0	....	6.5	....	
lb/lb. mol. mix	12.40	4.80	....	2.86	....	20.06
Per cent by wt.	61.8	23.9	....	14.3	....	
7. Per cent by vol.	50.6	10.9	....	0.1	38.4	
lb/lb. mol. mix.	8.10	3.27	....	0.04	10.75	22.16
Per cent by wt.	36.5	14.8	....	0.2	48.5	
8. Per cent by vol.	59.1	14.5	....	25.1	1.3	
lb/lb. mol. mix.	9.46	4.35	....	11.04	0.36	25.21
Per cent by wt.	37.5	17.3	....	43.8	1.4	
9. Per cent by vol.	32.3	67.0	....	....	0.7	
lb/lb. mol. mix.	5.17	20.10	....	....	0.20	25.47
Per cent by wt.	20.3	78.9	....	....	0.8	
10. Per cent by vol.	....	31.8	67.7	....	0.5	
lb/lb. mol. mix.	....	9.54	29.79	....	0.14	39.33
Per cent by wt.	....	24.2	75.7	....	0.1	

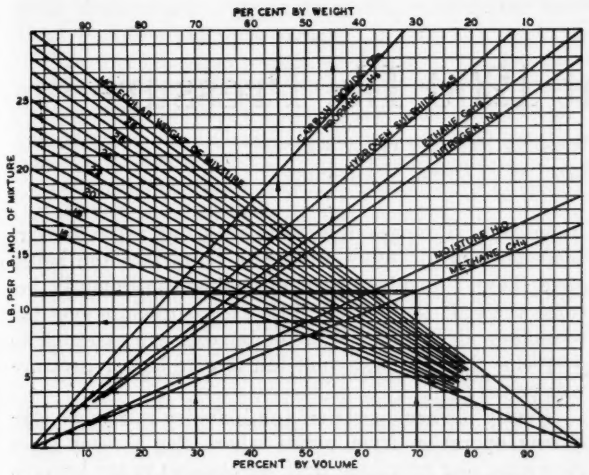


FIG. 2. CHART FOR CONVERTING VOLUMETRIC TO GRAVIMETRIC ANALYSIS

the molecular volume of methane is 359 cu. ft. at 32 deg. F. but is 379 cu. ft. at 60 deg. F.

5. The density of a gas is the weight per cubic foot at a given temperature and pressure. Gas densities may be readily calculated from the above mol relationship of weight and volume. Thus the density of methane at 32 deg. F. and 14.7 lb. pressure is equal to the quotient of 16 ÷ 359 = 0.0445 lb. per cu. ft. while at 60 deg. the quotient is 16 ÷ 379 = 0.0422 lb. per cu. ft.

Because of the present popularity of natural gas fuel, several typical samples of different composition have been chosen for comparison and the method of calculation developed for this type of fuel. In Table I, the volumetric analysis, gross heat value per cubic foot at 60 deg. F. and 14.7 lb. pressure and the calculated molecular weights and densities of these samples, is given.

Conversion of Volumetric Analysis to Gravimetric Analysis

Conversion of the volumetric analysis into gravimetric requires the use of the five principles given above, a table of the molecular weights of the various constituents of the gas, and a knowledge of the method of calculating the molecular weight of a mixture. A list of the molecular weights of the usual constituents of natural gas fuels is given in Table II. The molecular weight of a mixture is the sum of the fractional mols of all of the constituents. Its calculation is best shown by actual example as follows:

Constituent	Per cent by vol.	Mol. of constituent per mol. of mixture		Molecular weight of constituent		Pounds of constituent per pound mol. of mixture	Per cent by wt.
Methane CH_4	98.5	0.985	×	16	=	15.76	97.4
Nitrogen N_2	1.5	0.015	×	28	=	0.42	2.6
	100.0	1.000 Mol of Mixture				16.18	100.0

The sample contains 0.985 mol or 15.76 lb. of methane and 0.015 mol or 0.42 lb. of nitrogen. The sum of these weights gives the molecular weight of the mixture and per cent by weight of each constituent can be easily calculated in the usual manner. The percentage of methane in the sample is 15.76 ÷ 16.18 = 98.4 per cent and the percentage of nitrogen is 0.42 ÷ 16.18 = 2.6.

In Table III, the conversion of the analysis of the natural gas samples given in Table I is developed.

Figure 2 is a chart for converting volumetric to gravimetric analyses and is used as follows: Assume a gas mixture of 70 per cent methane and 30 per cent ethane. Following the guide lines up to the respective methane and ethane lines and across to the left, it is found that a mol of the gas mixture will contain 11.2 and 9.0 lb. respectively of methane and ethane. Adding these weights gives the molecular weight of the mixture equal to 20.2 lb. Following the guide lines to the right to the molecular weight line, 20.2, and up to the per cent by weight scale, shows that 11.2 and 9.0 lb. are respectively 55 and 45 per cent by weight of the total (20.2 lb.). Similarly for any gas mixture, the pounds per pound mol of the mixture is determined for each constituent and the sum of these weights gives the molecular weight of the mixture. The per cent by weight of each constituent is then determined by following each individual weight across to the proper molecular weight line and up to the per cent by weight scale.

Calculation of the Ultimate Analysis

Combustible elements of natural gas fuels consist of carbon and hydrogen. The non-combustible elements are nitrogen, helium, carbon from carbon dioxide, and hydrogen from water vapor. The per cent by weight of each may be calculated by multiplying the per cent by weight of each constituent by the per cent by weight of the element in the constituent and adding up similar items. In Table II is given the per cent by weight of each element in the usual constituents of natural gas fuels and the ultimate analysis of Sample No. 8 is developed as follows:

	Methane CH_4		Ethane C_2H_6		Carbon dioxide CO_2	Nitrogen N_2		Total
Per cent by weight in sample	37.5		17.3		43.8	1.4		100.0
Hydrogen								
Per cent in constituent	25.00		20.00		....	....		
Per cent in mixture	9.38	+	3.46		....	....	=	12.84
Carbon								
Per cent in constituent	75.00		80.00		27.27*	....		
Per cent in mixture	28.12	+	13.84	+	11.95*	....	=	53.91
Oxygen								
Per cent in constituent	....		....		72.73	....		
Per cent in mixture	....		....		31.85	....	=	31.85
Nitrogen								
Per cent in constituent	....		....		....	100.00		
Per cent in mixture	....		....		....	1.40	=	1.40

*Noncombustible carbon.

In a similar manner the ultimate analysis of any mixture may be determined and in the second article of this series, the relationship between the ultimate analysis and the heat value of these samples will be shown.

Inefficient brine pumps of the centrifugal type add a double burden to the cost of operation of the ice plant. They require extra power to operate and this extra power is absorbed by the liquid and appears in the form of heat, so that it adds to the refrigerating load. Efficiency is of increased importance with low coefficients of performance and high brine pressure. Inefficient cooling water pumps load up the cooling system and require the pumping of more water which, in turn, increases the friction head and cost of pumping.

Operation of Plants at 1200 Lb. Pressure

PLANTS OPERATING AT HIGH PRESSURE PRESENT ONLY FEW DIFFICULTIES NOT ENCOUNTERED AT LOWER PRESSURES

TWO PAPERS presented before the A.S.M.E. December meeting dealt with operation of 1200-lb. steam stations. In one, E. M. Gilbert, president of W. S. Barstow & Co., told of the Gilbert Station, formerly known as Holland Station, described in Power Plant Engineering, Mar. 1, 1929, p. 282. The other by K. M. Irwin, mechanical engineer, United Gas Improvement Co., was on Deepwater Station, see Nov. 15, 1929 issue, p. 1204.

For the period from Mar. 1 to Sept. 1, tabulated results show that, after the first month of breaking in, when the unit was run from 13 to 126 hr. a week, it has given weekly service from 113 to 168 hr. at station load

Date and time	August 19, 1930, 2:30 p.m.	
Station load:		
Kilowatt gross	52,000	
Boiler No.	1	2
1000 lb. steam per hour	218	218
Steam pressure	1265	1265
Steam temperature out of superheater	770.0	754.7
Steam temperature in reheater	543.5	543.5
Steam temperature out of reheater	808.6	818.8
Steam pressure in reheater	415.0	415.0
Steam pressure out reheater	410.0	410.0
Economizer:		
Gas temperature in economizer	935.0	937.2
Gas temperature out of economizer	550.0	557.6
Water temperature in economizer	363.0	365.0
Water temperature out of economizer	505.0	494.4
Air preheater:		
Gas temperature in preheater	550.0	557.6
Gas temperature out of preheater	312.0	308.3
Air temperature in preheater	85.0	85.0
Air temperature out of preheater (left)	410.0	405.0
Air temperature out of preheater (right)	420.0	412.6
Flue-gas analysis:		
CO_2 in economizer	13.13	13.53
Condenser:		
Barometer	29.86	....
Vacuum	28.20	....
Circulating-water temperature, in	73	....
Evaporator:		
Make-up water, lb. per hour	7200	
Make-up water temperature	70	

TYPICAL OPERATING DATA FROM GILBERT STATION

factor from 25.44 to 89.6 per cent; coal of about 14,000 B.t.u., from 0.846 to 0.987 lb. per kw-hr. and 11,866 to 13,844 B.t.u. per kw-hr. Thermal efficiency was 24.65 to 28.75 per cent, most of the time being 25 to 27.5 per cent. Average operating data for a typical day are shown in the table.

Mr. Gilbert states that wherever difficulties were encountered, manufacturers of equipment gave fullest cooperation and any failure to overcome trouble has been due to lack of time for ironing out the kinks.

Boiler Room

Leaks around economizer handhole caps were remedied by using softer steel gasket. For leaks between tubes and headers, work is in progress but the final cure cannot yet be given.

Induced draft fan inlet vanes showed erosion due to high velocity of gases when vanes were almost closed for light loads. Leak-in dampers for light loads and starting solved this problem.

With original installation of burners, flame went below the slag screen, which was overcome by changes in position. Changes in burners are being made to overcome burning of cones, also mill vents into the boiler have showed burning when operating continuously because the vent fan had too little excess pressure over the secondary air. Changes in the burners are expected to overcome this; if not, a vent fan to give higher pressure will be used.

Faulty burner operation and inability to remove slag during operation from points where slag screens cross gave some slag trouble at first but changes in the burners and additional ash pit doors have solved the problem.

On secondary feed pumps, Ryan seals were replaced by a combination labyrinth and stuffing-box which has proved satisfactory. Rearrangement of piping overcame difficulty with the pump oiling system. A Mercon regulator has been installed between primary and secondary feed pumps to hold high-temperature water in the secondary pump when running at light load. For emergency, a turbine-driven feed pump has served well during trouble with the main turbine, which put motor-driven pumps out of use. Its only trouble has been from a piece of concrete left in the suction which threw the pump out of balance and caused freezing of the runner and wearing ring.

Pollution of the Delaware River by factories and sewage systems caused trouble during the dry season, as the make-up evaporator had to work at full capacity due to excessive leakage of economizer tubes. Concentration in evaporators and boilers was increased so that solids were carried into the turbine and deposited, reducing its efficiency and capacity. Washing out with saturated steam has aided but final work is not completed. With greater care to keep down concentration in the evaporators, no further difficulties from scale in the turbine are expected.

Piping and Turbines

All pipe joints are gasketed, the flanges for high pressure being 35 to 50 per cent stronger than the 1350-lb. standard. Early in operation, composition gaskets gave trouble on high-pressure lines, 2 in. and under; replacement by metal gaskets has been satisfactory, while composition gaskets work well on low-pressure lines.

Covered flanges on high-pressure superheated lines developed leaks due to change of temperature when being brought up to pressure or taken out of use. Removal of flange covering stopped this effect.

In the beginning, some condensation from high-pressure turbine glands got into the oiling system. Valve stems stuck in their bushings, also the cam mechanism of the valve control bothered by sticking. Alterations have overcome all this.

Leaks in horizontal joints of the high-pressure turbine casing were stopped by tightening the holding-down bolts. Faulty adjustment of the vacuum tripper was taken care of and, though no trouble has been encount-

ered, changes are being made in the intercepting valve to give more rigid construction.

The gas reheaters proved too large, giving too great a reheat temperature, which necessitated desuperheating during early operation. Removing some reheater surface stopped the difficulty. Faulty welding of the high-pressure elements of the steam reheater was found but that reheater has been used only occasionally as the gas reheater gives more than enough temperature. At the start, superheat was low but has been adjusted by installation of a kicker baffle.

Loss in the circulating system, from leakage between the rubber expansion joints and the water boxes, has been overcome by a change in bolting arrangement.

During starting, the reciprocating air pump pulled water from the seal between the first stage jet and the condenser into the cylinder, causing a cracked head. This was corrected by installing a bypass around the first stage jet, for use when starting up.

Deepwater Data

Pulverized coal is used, half the plant being on the bin system and half on the unit system with two 10-t. mills to each boiler. One 20-t. mill serves each boiler on the bin system, drying being by preheated air introduced into the mills, excess air being vented beyond the cyclone exhauster into the secondary air chamber for the burners. Cyclone discharge into the powdered coal bins in front of each boiler, a screw conveyor making it possible to use any mill for any boiler. Each boiler has six burners supplied by feeders directly below the bunkers.

Slag-tap furnaces are used with high-pressure water jets to break up and quench the slag stream.

Piping

No difficulties have been encountered with larger sizes. On smaller sizes, and valve bonnets, composition gaskets caused some trouble, which was overcome by the use of soft steel or monel-metal gaskets.

Furnaces

Leaks in economizers and water walls have been stopped by better preparation of flange faces, better installation of gaskets and rerolling of tubes. Slopping of quenching water onto some tubes caused some leaks.

For slag tap furnaces whose boilers are taken off and put back on line frequently, there is a tendency for furnace floors to grow and push out the side walls, because the bottoms crack on cooling and the cracks are filled with molten slag. Dolomite floors have proved better than mica scist. Minor slag leaks were stopped by chilling with water and the floor cut back 6 in. along two sides. After walls assumed their normal position, the spaces were filled with silica sand. If boilers are cut in and out infrequently, bottoms may be operated for a year without serious maintenance work.

Trial of coke bottoms showed that the coke is penetrated and consumed by the iron sulphide in the slag, which sinks in the bottom and is not drawn out through the slag tap.

Slag erosion affected the refractory backing of rear walls so that three of them were replaced. Investigation is now under way to get for the tubes a refractory backing which will be less subject to erosion.

Firing Systems

No careful comparison of the economy of bin and unit pulverizer systems has been made but normal operation seems to indicate equal efficiencies. In flexibility neither has an advantage although the bin system can be cut down to lower output than the direct fired system.

Oil had to be used for drying out the direct-fired furnaces. As the fire was small for so much water wall, apparently some oil vapor passed through the boiler and condensed in breechings and stacks as greasy soot. This caught fire on two occasion, two men being, unfortunately, injured on one of them.

Because of less bulk, the direct-fired system has a better appearance at the boiler front but, due to faulty lubrication of the mills, it has sometimes been necessary to cut down the load on direct-fired boilers, while adjustments were made. These interruptions seem to have been overcome by correcting the lubrication.

Because the mills are quiet and do not become noisy when coal feed fails, loss of fuel and pressure has occured at times, due to operators not realizing that coal feed had stopped. This is a matter of operating which will be overcome with more experience. The coal has hung up in raw coal bunkers, stuck in connections between coal bunkers and scales, jammed in the scales and been stopped by pieces of wood or foreign material in the mills themselves. These conditions are being overcome and it is hoped will be entirely eliminated.

Mr. Irwin, who advocated the bin system at the start, feels that it is desirable to have on hand a 2 to 3-hr. supply in bins.

Turbines

On the high-pressure unit which uses exhaust for process work, hence requires considerable make-up water, silica scale has formed on the last rows of blading and nozzles. The silica is soluble in water at high temperature, hence this difficulty is due to the high pressure. The scale has been scraped by hand but it is understood that it can be washed off by running saturated steam through the turbine. Purification of steam from the house evaporators has, however, seemed to overcome the trouble.

Horizontal joints in the casings have been tightened to stop leaks and changes in governor mechanism have overcome difficulties there. The control valve for admitting high-pressure steam to low-pressure elements has been redesigned, as it was found that the stem broke when trying to operate it for running the low-pressure element without the high-pressure.

Few difficulties have been met which were due to pressure and temperature and those are well on the way to correction.

South Amboy Plant

As part of the discussion of these two papers, R. C. Roe and J. P. Mailler of the Electric Management and Engineering Corp. gave their experiences in operating South Amboy Plant of the Jersey Central Power & Light Co. This plant designed for operation at 1400 lb. pressure was described in detail in the July 15, 1930 issue of Power Plant Engineering and consists of two 25,000-kw. steam turbines served by three boilers, each having a normal capacity of 250,000 lb. of steam an hour.

Some of the unusual features of this station are:

The use of unit boiler-turbine construction, one boiler per turbine with a spare boiler applicable to either turbine, which eventually will be used for the third turbine.

The use of double deck, compound turbines as a single unit without provision for separate operation.

The use of a five-point regenerative cycle with direct contact heaters on all stages, eliminating drip pumps or condensate cascading and bringing terminal differences practically to zero, with expected improvement in over all thermal efficiency.

The use of premeasuring devices for coal and air and individual mills per burner with multiple burners per boiler, permitting great flexibility and accurate predetermination of combustion conditions prior to the actual combustion.

South Amboy Plant is now in its preliminary operating stage in a commercial way and has not had sufficient operating experience so that much can be said about its operating characteristics, except as covered by experience to date.

At the present time, both turbines and two of the boilers have been operated under load and the plant has carried load continuously for about a month. The starting troubles which have occurred to date in this station have been minor and have been less than is usually to be expected in starting a new station. In the entire starting operation a total of two small gaskets and one valve bonnet gasket have been lost. No joint failure of any of the main steam or reheat lines or any trouble with these steam lines has occurred. Two cases of tube leakage in the boilers in their seats, one of which has been repeated several times, have been experienced. One of these cases was due to improper rolling on erection and the other case was due to failure to provide properly for expansion stresses in the design. These two cases are of minor nature and are a small percentage considering the large number of rolled joints involved in one of these boilers. No major trouble from this source is anticipated.

Ignition burners are provided for each coal burner. These have operated satisfactorily and have been a material help in eliminating the difficulties of the starting period.

No serious trouble has been experienced with the boiler feed pumps, although steps are being taken to modify one set of these boiler feed pumps to make it slightly less sensitive and to provide a better packing arrangement. It is probable that similar steps may need to be taken with the other pumps. This matter, however, is well in hand and the pumps have operated satisfactorily to the extent that no difficulty has been encountered in putting water in our boilers.

The circulating pumps on the condensers are equipped with synchronous motors. Some difficulty has been experienced with the pull-in torque of these motors. This is being corrected now and in the meantime the station is not suffering from this feature.

Turbine operation has been excellent, the only trouble having occurred on this being one case where too much or too little lubrication was put on the valve mechanism and it had a tendency to bind. No trouble has been experienced from the growing of parts in this mechanism and the operation of the turbine governor has been extremely good.

Beyond the usual adjustment of apparatus, this has been the total of the plant starting troubles of any major nature which have occurred to date.

Selecting the Correct Type of Engine Drive

A Review of Fundamentals Entering the Correct Solution of Prime Mover Selection With Particular Reference to the Modern Laundry. By J. M. Maag*

AMONG THE FACTORS tending to eliminate the uneconomical prime mover from laundry service, the most important are the heavy increase in the demand for electrical power, with no corresponding increase in the demand for hot water, and the advent of the heat reclaimer, reclaiming a portion of the heat in the waste water formerly discharged to the sewer.

With the tendency today towards complete electrification, boiler room accessories in the modern laundry are motor driven, shirt and finished work presses are operated by air furnished by motor driven compressors and flat work ironers, extractors and tumblers are equipped with individual electric drives. Washers are operated either from a system of line shafting with one or more electric motors or in the case of the larger all-metal washers each machine is equipped with an individual reversing motor.

In recent years there has been a marked increase in the amount of finished and rough-dry work with flat work ironed as compared with the strictly wet wash business. This means more electric power for ironers, presses and tumblers. Furthermore modern standards of working conditions require good ventilation, usually with one or more motor-driven fans, while efficient operating methods require conveying systems and in multiple story plants with motor-driven elevators.

In selecting the prime mover, it is important to determine whether the uniflow, four-valve counter flow, single-valve engine or turbine will best meet the power and heat requirements for that particular installation. In making an investigation of these prime movers two things must be known: first, the load in kilowatt-hours or horsepower hours if the generator is not used; second, the amount of low pressure steam required.

Loads Vary Throughout the Week

In an existing plant the first item can be estimated from the power bills and the total connected load but the most accurate method is to install a recording wattmeter. As the variation of the load from day to day and hour to hour is important, most laundries, with the exception of linen supply houses, find it difficult to proportion the work evenly throughout the week. Monday, Tuesday and Wednesday are usually the heaviest days

*Sales Engineer, Elliott Co.

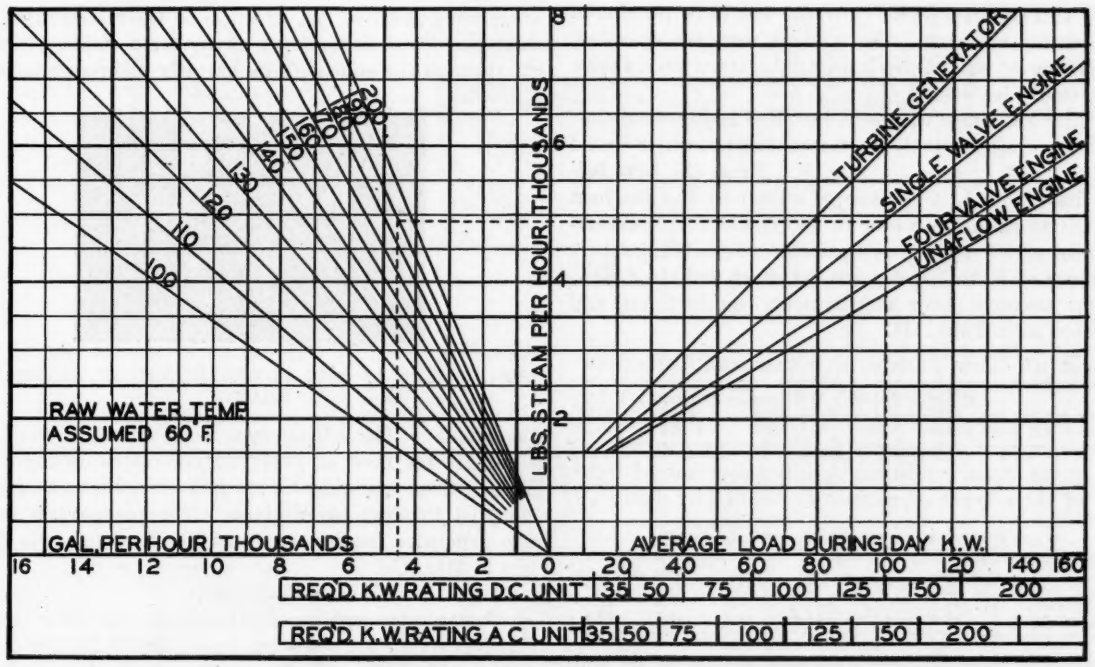
and the load tapers off until only a small amount of work is left for Saturday. Under this condition, it may be necessary to use live steam for water heating during the early part of the week and waste exhaust steam to the atmosphere during the latter part of the week.

Determining the amount of low pressure steam required is usually easier than estimating the load demand. The load is determined directly from the amount of hot water used as steam for heating the plant may usually be ignored. If a correct heat balance is determined for the non-heating season, no exhaust steam will be wasted during the winter.

of necessity refer to one steam condition only. Definite steam guarantees for particular values for initial steam pressure and exhaust pressure should be obtained from the engine or turbine manufacturer and the exhaust steam available for any particular installation calculated from these figures.

Generator Efficiencies Important

Steam guarantees on a generator unit should always be obtained on the basis of pounds of steam required per kilowatt-hour and not indicated horsepower-hour. The former guarantees include all the losses of both engine



HEAT BALANCE CHART

HOW THE CHART IS USED.—Suppose, for example, you need an average of 4500 gal. per hr. of water at a temperature of 190 deg. F. and that the average load in your plant is 100 kw. From the point on the horizontal base line indicated as 4500 gal. per hr., move vertically to intersect the diagonal line marked 190 deg., then move to the right horizontally and you will see by the vertical scale that it requires approximately 4900 lb. per hr. of exhaust steam to heat the water to the required temperature. Continue horizontally until you intersect the vertical line through the point representing 100 kw. load on the base line. This intersection comes very nearly on the diagonal line for the single-valve engine, indicating that this type of generating unit will give the best heat balance.

Referring to the lower lines of the chart, if you use direct current, a unit rated at 125 kw. will be the best size to install and if alternating current is used a 150-kw. unit should be the proper size. Further reference to the chart will show that if 4900 lb. of exhaust steam are required, a unaflow engine will generate 140 kw. per hr. on this amount, a four-valve engine 130 kw. and a turbine 80 kw.

These figures are based on average pressure and exhaust conditions and so are necessarily approximate; however, the relative comparison should come very close to actual results.

The amount of steam in pounds required to heat a given amount of water in gallons can be determined from Fig. 1. This chart is drawn for a temperature rise of 40 to 140 deg. F., the temperature of the water going to the heater being assumed as 60 deg. F. If the temperature is higher or lower than this, the chart will work just as well, bearing in mind the temperature range over which the water is to be heated. For example, if the incoming water is 80 deg. F. and it is desired to heat it to 180 deg. F., the temperature rise is 100 and it would require the same quantity of steam as it would to heat the water from 60 to 160 deg. F.

This chart also illustrates graphically the amount of steam available for heating water from different types of prime movers with the engine operating at different loads. These must be considered as typical values and and generator, while the latter does not take into consideration engine friction, losses in the generator, nor, in the case of alternating current generators, exciter losses. The consideration of generator efficiency is important as there may be sufficient difference in the efficiencies of two generators for a particular load to cause a material difference in the steam consumption for a given electrical load.

With daily power and heat requirements obtained, a tabulation should be made, for each day of the week, showing the amount of low pressure steam required for heating the water and the amount available for the various types of engines. From the integrating wattmeter of a certain laundry the kilowatt consumption for light and power for a typical week was found to be as shown by Table I.

TABLE I. POWER CONSUMPTION IN KILOWATT HOURS PER DAY

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
810	864	972	904	692	256

Hot water requirements in gallons per hour for each day of the week were as shown in Table II.

TABLE II. HOT WATER REQUIREMENTS IN GALLONS PER HOUR

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6000	7000	7500	7000	5000	

It was decided to contract for sufficient standby power of a local utility company to operate part of the plant in the event of a shutdown of the engine. In order to use up this standby service, current was to be purchased on Saturday morning. The washers were not operated, no hot water was to be heated, therefore no exhaust steam would be wasted.

A heat reclaimer was to be installed at the same time and it was conservatively estimated that the water would leave the reclaimer at 100 deg. F. From the heat balance chart, Fig. 1, it is a simple matter to find the heat required to raise this water to 180 deg. F. A temperature rise of 80 deg. F. is equivalent to a temperature difference of 60 to 140 deg. on the chart and the following low pressure steam requirements can be found and tabulated as in Table III.

TABLE III. LOW PRESSURE STEAM REQUIREMENTS

	Monday	Tuesday	Wednesday	Thursday	Friday
Lb. per hr.....	4000	4650	5000	4650	3350
Lb. per 9 hr. day...	36000	41850	45000	41850	30150

For the steam conditions specified guaranteed water rates of three types of engines are shown by Table IV.

TABLE IV. WATER RATE GUARANTEES

	¼	½	¾	4/4	5/4	Av. Load
Unaflow	42.8	34.5	32.6	33.0	34.4	35.0
Four-valve	48.8	36.3	34.2	34.9	38.0	37.7
Single-valve	62.8	47.2	42.8	44.8	49.2	47.9

The average steam consumption was arrived at by adding the rates of ¼, ½, twice ¾, 4/4 and 5/4 load and dividing by 6. In the absence of definite load curves for the hours of the day, this method is sufficiently accurate for estimating purposes. By multiplying the total kilowatt-hour consumed per day by the average steam consumption per kilowatt-hour it is possible to determine the total steam consumption in pounds for each engine. From the data given above, this would be as tabulated in Table V.

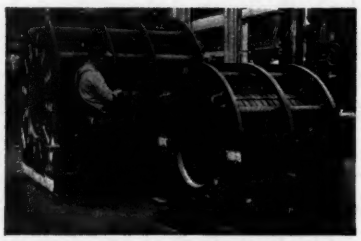
TABLE V. STEAM CONSUMPTION OF DIFFERENT ENGINES

	Monday	Tuesday	Wednesday	Thursday	Friday
Unaflow	28,350	30,240	34,020	31,640	24,220
Four-valve ...	30,537	32,573	36,644	34,080	25,088
Single-valve ..	38,799	41,385	46,558	43,301	33,146

By comparing the low pressure steam required per day with the steam available from the three different types of engines, it will be seen that if the single valve engine is used, steam will be wasted to the atmosphere several days each week. If a four-valve engine is used, no steam will be wasted and it will be necessary to make up the deficiency by supplying steam direct from the boiler through a thermostatically controlled reducing valve. In this case a four-valve engine was purchased because it was the logical solution. The single-valve engine would have been too wasteful of steam and the additional investment for a unaflow could not be justified. No advantage could be taken of the slightly better economy. The greatest portion of the wash in this plant happened to be wet wash, but with the selected arrangement, a considerable increase in the percentage of finished clothes could be handled without endangering the heat balance.

Pipe Construction for Generator Frames

WELDED PIPES are replacing the usual ribs made of flat bars welded into notches on the outside of turbine generator frames according to the latest construction practices. In addition to their structural advantages, these tubes serve as air ducts, taking cooling air through the ends and discharging it through holes in



USE OF PIPE IN THE CONSTRUCTION OF GENERATOR FRAMES

the middle. The lifting eyes welded on the endplates eliminate the need of heavy lifting plates on the sides. These lifting eyes may be reached after the generator is enclosed through cover plates. The photograph shows two generator frames set up at the Westinghouse Electric & Mfg. Co.

COMMERCIAL STOCKS of bituminous coal used largely for industrial purposes amounted to 37,200,000 t. on January 1, 1931, according to the quarterly survey recently completed by the United States Bureau of Mines, Department of Commerce. In comparison with the amount on hand at the beginning of the previous quarter, this is an increase of 1,300,000 t. but it is 3,100,000 t. less than the quantity in storage on the same date last year.

Exports during the last quarter of 1930 averaged 331,000 t. a week, as against 382,000 t. in the preceding quarter. The weekly rate of consumption within the United States during the fourth quarter of 1930 amounted to 8,987,000 t., as compared with 7,370,000 t. in the previous quarter. In comparison with the average weekly rate of consumption during November and December, 1929, however, the rate of home consumption plus exports for the period under review shows a decrease of 16.6 per cent.

In addition to the stocks in the hands of consumers, there was 8,940,000 t. of bituminous coal on hand on the docks of Lake Superior and Lake Michigan on January 1, as compared with 9,804,000 t. on October 1.

Stocks of anthracite in retail yards on January 1 have declined since October 1 and are also a little less than on the corresponding dates of other recent years. In terms of days' supply, the present stocks of anthracite are equivalent to 43 days' requirements.

Regulating Double Extraction Turbine Pressures

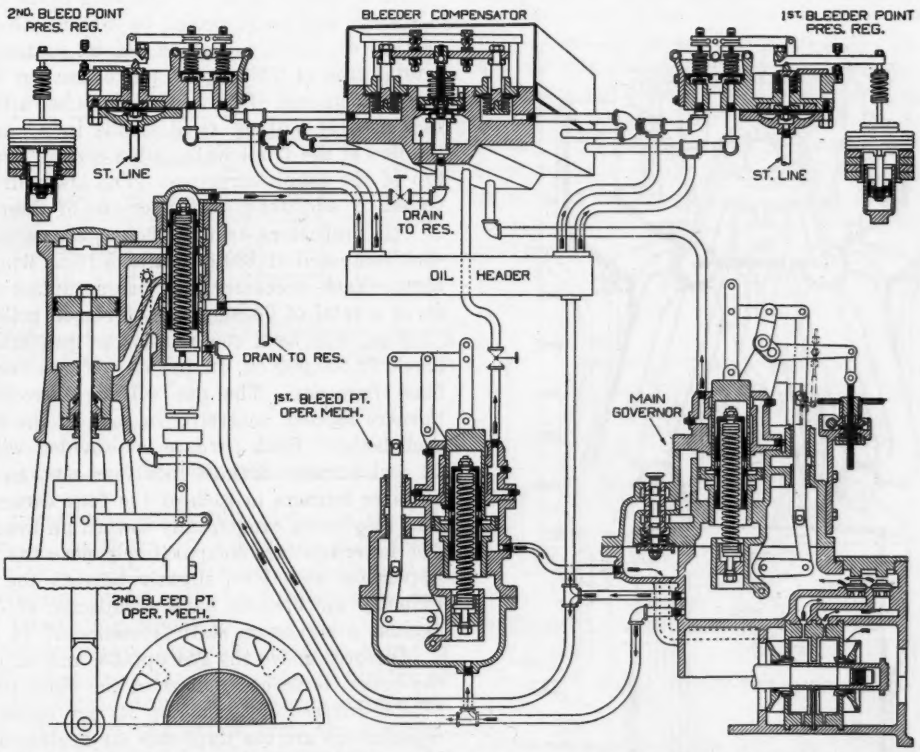
NEW GOVERNOR MAINTAINS CONSTANT PRESSURE AT TWO BLEEDER POINTS AND VARIES THE ADMISSION OF STEAM TO THE TURBINE TO CARRY THE REQUIRED ELECTRICAL LOAD

EXTRACTION or bleeder turbines have of recent years had a phenomenal growth in the industrial and central station field. In the central station field bled steam is invariably used for feedwater heating in closed heaters and no pressure regulation is required, the pressure of the heater being allowed to vary with the load. In industrial plants, especially when the steam is used for process work, pressure regulation is of considerable importance and the single bleeder units have been widely equipped with automatically controlled bleeder pressure regulators.

Industrial demands have, however, outgrown the single bleeder turbine and a number of double bleeder units have been installed. It is usual to have only one bleeder stage automatically controlled although automatic devices have been developed. One of these is a new and ingenious hydraulic double bleeder compensator recently developed by Westinghouse for use in connection with the oil impeller governor. This device, which is shown in the accompanying illustration, will maintain constant bleeder pressure at two bleeder points and vary the admission of steam to the turbine accordingly to carry the required electrical load.

The fundamental feature upon which the device is based is the fact that in the oil governor the relay is moved by the governor oil pressure against the tension of a coil spring, the pressure varying as the square of the speed with the result that there is a definite position of the relay for every speed. It is, therefore, possible to alter the speed corresponding to a given relay position by means of a counter pressure applied to the opposite end of the relay piston and this back pressure may be controlled by relief valves actuated by a diaphragm under pressure from the bleeder line.

In the case of the double bleeder, each bleeder stage is provided with a pressure regulator, as shown in the illustration, and a bleeder operating mechanism identical in principle with the speed control governor. The bleeder compensator, newly developed, is the heart of this system and consists essentially of three relief valves, communicating severally with the speed control governor relay, the first bleeder operating mechanism relay and the second bleeder operating mechanism relay. Each of these valves is in turn connected through levers to two diaphragms subjected to pressure controlled by the bleeder pressure regulator relief valves. As may be seen in the illustration, these are so piped up that a change of pressure at either bleed points affect the other bleed point and also the main governor and any change in the main governor caused by a change in load is communicated to both bleed points.



ARRANGEMENT AND CONSTRUCTION OF THE DOUBLE BLEEDER TURBINE GOVERNOR

GENERATORS for high voltages, such as 22,000 v., are larger and cost more to build because of the space required for conductor insulation. When economically justified, the cost savings with high voltages result from the circuit breakers, cables and auxiliary equipment.

Ford Completes Largest High-Pressure Plant

TWO 700,000-LB. PER HR., 1400-LB. BOILERS AND 110,000-KW. STEEPLE COMPOUND TURBINE WITH STEAM REHEATERS IN RIVER ROUGE ADDITION

IN ORDER that it may increase its capacity for immediate and future needs, the main power system of the Ford Motor Co., at Dearborn, Michigan, has been augmented by the installation of two new 700,000-lb. per hr., high-pressure boiler units; 110,000-kw. steeple-type turbine-generator; a turbo-blower of 70,000 c.f.m.

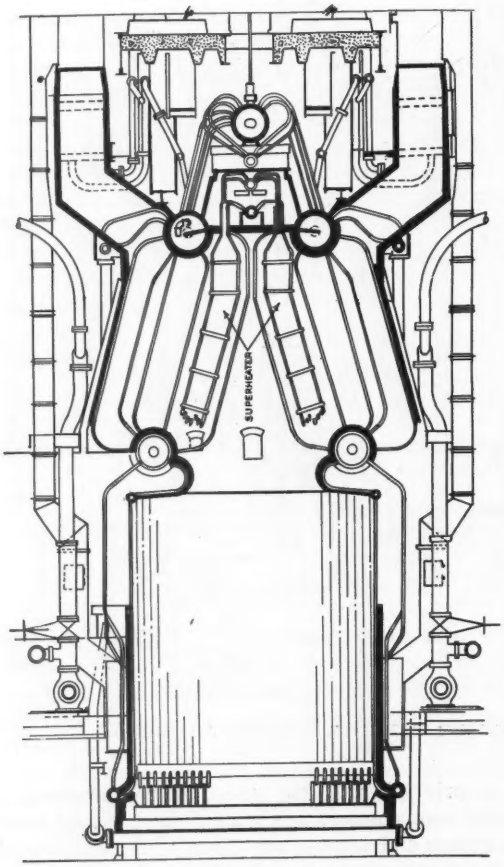


FIG. 1. SECTION OF NEW BOILERS

capacity; and the building of a water tunnel more than 2 mi. long to provide not only more cooling water but water at a lower temperature than has heretofore been available. Capacity which will be added by the above noted units, plus those already existing, will give the Rouge Plant No. 1 power house a total electrical capacity of approximately 230,000 kw. All will be used in the manufacture of Ford cars and trucks or in operating machinery incidental to their production.

New boiler units consist of two double-set Ladd boilers, each furnishing a water-heating surface of 37,266 sq. ft. (11,466 sq. ft. superheater) and with a capacity of 700,000 lb. per hr. of 1400 lb., 750 deg. F. steam. The unusual feature, from an engineering standpoint, is that these new boilers are installed in almost identically the same space formerly occupied by two displaced boilers which yielded only about one-third of the capacity. This is being effected principally by adding additional side wall tubes to the boilers to increase the heating surfaces.

Each furnace is 25 ft. 8 in. long by 26 ft. 8 in. wide. All walls will be protected by water-cooled surfaces of vertical fin tubes, spaced on 5¼ in. centers, and having a total area of 5234 sq. ft. per boiler. A bottom water screen composed of 60 3-in. plain tubes affording a surface area of 770 sq. ft. descends in a curve from the headers at the front walls into a central drum below the top of the ashpit structure. The lower drums are protected by additional water screens of finned tubing.

Air preheaters, two per boiler, are of the plate type, each composed of 180 elements, 5 ft. in width and 18 ft. high. Each preheater unit has a surface of 32,400 sq. ft. or a total of 64,800 sq. ft. for each boiler.

Fuel will be a combination of pulverized coal and about 92,000,000 cu. ft. per day of gas from the Rouge blast furnaces. The gas will be introduced through burners located, centrally, in each of the two fronts of each boiler. Each furnace is provided with a total of 12 coal burners divided into four sets, an upright row of three burners in each of the four corners and so set that they point tangentially toward an imaginary circle. The lowermost are comparatively near the floor and the uppermost at a level slightly beneath the gas burners. Primary air blowers have a capacity of 50,000 c.f.m., against a maximum static pressure of 14 in. of water.

Directly above the gas uptake, and on either side of the boiler, is an economizer of the plain tube type with a total surface of 14,000 sq. ft. per boiler. Above the economizers are the duplicate air heaters and, at a still higher level, two induced draft fans of a capacity of 210,000 c.f.m. driven by 636-hp., two-speed motors. The fans have been so located as to discharge squarely into the base of the stack. At a corresponding level both boilers are fitted with a quartet of forced-draft fans of 50,000 c.f.m. each, that will draw warm air from the top of the boiler room and discharge it through the preheaters to the furnace wall ducts and the burners. These are driven by 126-hp. motors.

THE NEW TURBINE-GENERATOR

The new steeple compound turbine-generator which is to be driven with steam generated by the new boilers, will have a capacity of 110,000 kw. at 90 per cent power factor. A feature is that the high-pressure element will be mounted above the low-pressure element, thus conserving floor space. Both will rotate at a common speed of 1800 revolutions per minute. Since both pressure sections will have a capacity of 55,000 kw., their electric generators will be identically wound for production of three-phase, 60-cycle alternating current at 13,800 v. The generators will be separately excited.

At either side of the unit will be located live-steam

reheaters. Passing through these, upon leaving the high-pressure turbine, the steam will be raised to a temperature of 550 deg. F. before entering the low-pressure turbine. There are 12 stages in the high-pressure turbine. The first of these has a double row wheel but the remaining eleven are of the single-row type. The low-pressure turbine is double flow with 10 stages on either side of a central steam admission.

Steam at the throttle will be 1215 lb. abs., 725 deg. F. and will exhaust from the high-pressure turbine at a

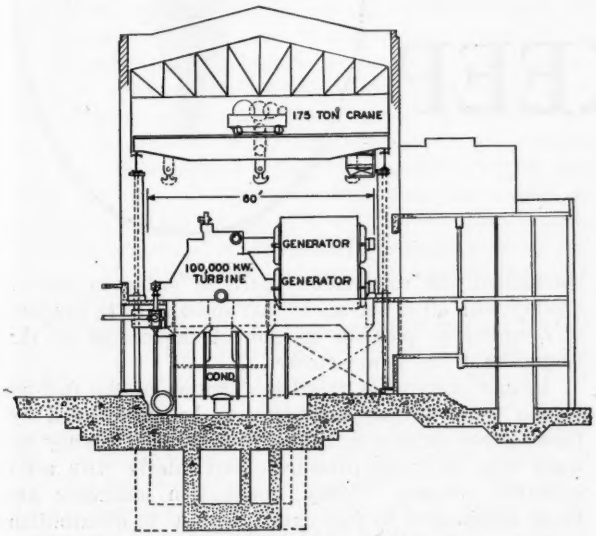


FIG. 2. ARRANGEMENT OF TURBINE UNIT

approximate pressure of 80 lb. abs. Leaving the low-pressure element, the steam will exhaust to a 77,000-sq. ft. surface condenser with 12,200 tubes, each 28 ft. 2 in. in length. Cooling water will be furnished by two 80,000-g.p.m. circulating pumps.

To heat the feedwater, there will be four stages of bleeding: The first from the high-pressure turbine at 320 lb. abs.; the second from the crossover connection, at 85 lb. abs.; the third and fourth from the low-pressure turbine, at 31.5 and 8.8 lb. abs. respectively. The condensate will be taken from the hot well, forced through the air ejector and then through the generator air coolers and a low-pressure closed heater to a deaerating heater. Distilled water make-up will be delivered from a single effect horizontal evaporator, using steam extracted from the high pressure turbine.

A booster pump having an operating range of 35 to 780 lb. absolute, will take suction from the deaerating heater and force the boiler feed supply through the crossover and high-pressure heaters and a reheater drip cooler to the boiler feed pumps. The latter will have an operating range of 750 to 1615 lb. feed to the economizers at a temperature of approximately 437 deg. F. Space occupied is by the new turbine in relation to the output, less than 0.25 cu. ft. per kw. Its total length is but 57 ft. 6 in., its greatest width 23 ft. and the maximum height above the floor slightly under 21 ft.

The New Water Tunnel

The tunnel which is to supply cooling water was begun August 15. So far as is known, the tunnel is the largest ever built to serve the needs of a single industrial concern. Generally it is a true cylinder with an inside diameter of 15 ft. and an outside diameter of 21 ft. Two thicknesses make up its walls. The outer is composed of interlocking cement blocks, curved in the moulding process to conform to the arc of a cross section of the tunnel and 18 in. thick. The inner lining of equal thickness, is formed of monolithic concrete. The tunnel is 12,000 ft. long and is located 60 ft. below the surface of the ground. Ten curves are included, the longest covering a distance of 466 ft. The tunnel begins with an intake located on the old channel of the River Rouge, at a point about two-thirds of a mile from the Detroit River and ends with a pump well and house located in the lee of the Rouge Plant No. 1 power house.

The screen house structure is 44 by 104 ft. It is of brick, steel and concrete, floored with tile and contains all controls governing screens, gates, stop log, pumps, etc. It is served by a 10-ton overhead electric crane and heated by a small boiler stationed in an under floor room. Back of the screen house and also below grade level, is the discharge chamber. From a base practically as wide as the screen house is long, it swings gradually to the left, always narrowing, to resolve itself finally into the transition chamber which connects with the main tunnel. Assuming a 9,000,000-gal. consumption at the

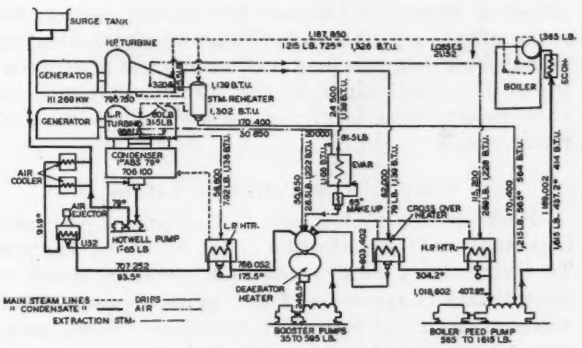


FIG. 3. HEAT BALANCE DIAGRAM

power house end of the line, the velocity of flowage in the tunnel will be at the rate of 7.9 ft. per sec.

The Pump Well

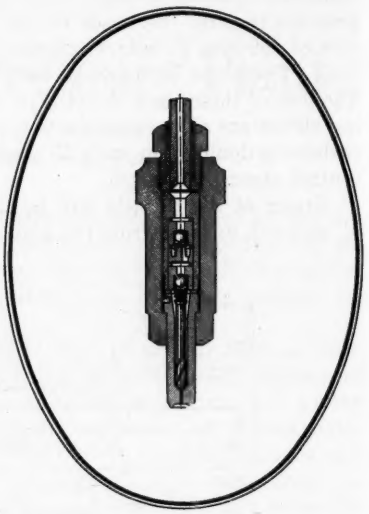
The pump well, located immediately adjacent to the power house is approximately 65 ft. deep, 70 ft. in outside diameter and walled by circular rings of reinforced concrete, 4 ft. thick. The bottom is floored by a mat, convexed on the under side, with a central thickness of 8 ft. tapering to 3 ft. 6 in. at the edge.

The boosting will be performed by four vertical propeller type pumps, with synchronous driving motors and control. The individual capacity will be 157,750 g.p.m., against a 14.5-ft. head.

Costs of 17 Diesel plants built by one company in the southwest range from $283 per kw. of generator capacity for a 60-kw. plant with one engine down to $122 per kw. for a 2400-kw. plant with six engines.

Cheap fuels usually do not warrant costly heat reclaiming devices.

DIESEL ENGINE UPKEEP



PART X. FUEL-INJECTION VALVE MAINTENANCE. SIGNIFICANCE OF PROPER FUEL INJECTION ACTION. DETECTION OF IMPROPER ACTION. PREVENTIVE PROCEDURE. TESTS FOR VALVE TIGHTNESS. REPAIR METHODS. REGULAR INSPECTION

MOST FORCED Diesel-engine shutdowns are caused by troubles with spray plugs and fuel pumps, breaking of spray-plug springs and carbonizing of nozzle tips but most of such shutdowns may be avoided by proper maintenance and operation procedure including periodical inspection, adequate provision of replacement parts, prompt repair before damage is great, attention to indicating and recording instruments and proper control of the combustion of the fuel. Fortunately, the cost of necessary replacement parts is low and the work of repair, small.

FUNCTIONS OF INJECTION VALVES

Fuel-injection valves, next to fuel pumps, are most important and characteristic parts of Diesel engines. To their correct construction and operation, much of the satisfactory operation of the engine depends. Such valves perform three distinct functions: First, properly timing the admission of fuel into the engine cylinders. Second, introducing the liquid fuel into the cylinders in a finely divided state as in atomized form. Third, projecting the fuel charge, as rapidly as possible, throughout the combustion space in order to mix it quickly with all of the air in that space so as to produce as complete as possible ignition of the charge at the beginning of the power stroke.

Proper exercise of this last function of the fuel-injection valve is only beginning to be appreciated by Diesel-power advocates, hence we find the tendency toward high injection pressures, particularly with solid injection systems. Today, combustion chambers are being designed to fit fuel sprays both as to distribution of the injected fuel and to location of the injection valve. No other single factor is so important to successful Diesel operation as proper functioning of the combustion space. Both rapid penetration and spread of the fuel spray, which results in proper mixture of the fuel and air in the combustion space and in adequate flame propagation hence prompt ignition, result in increased combustion efficiency. Lack of full exercise of these functions lead directly to spray nozzle and indirectly to other engine troubles.

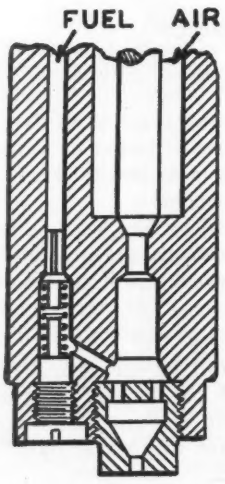


FIG. 1

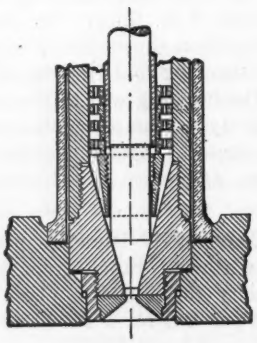


FIG. 2

FIG. 1. OPEN TYPE FUEL INJECTION VALVE
FIG. 2. CLOSED TYPE FUEL INJECTION VALVE

COMBUSTION AFFECTS ENGINE-PART MAINTENANCE

Increasingly, it is being realized that maintenance work, on what may seem to be unrelated engine parts such as valves, pistons and main bearings, is noticeably reduced by keeping the combustion process at highest possible efficiency. The reason for this is the impossibility of keeping carbon deposits and other impurities, formed during an improper combustion process, from mixing with lubricating oil. It is because of increasing appreciation of the fuel-injection valve as a combustion-

FIG. 3. ATOMIZER CONE, PLATES AND RINGS

mixer device that high-pressure solid injection directly into the combustion chamber is gaining favor over use of pre-combustion chambers. Importance of proper maintenance of fuel-injection valves, therefore, is apparent. It will be seen also that the amount and kind of attention required of a fuel-injection valve will differ according to the type of valve.

Importance of Adequate Fuel Diffusion

Air injection methods were first developed because Dr. Diesel was unable to inject the oil satisfactorily by direct pressure. Injection by air pressure continued to be the more popular because of the better combustible mixture obtained but recent spray experiments have shown the possibility of efficient mixing of the fuel and air by the production of turbulence in the combustion chamber by the use of high-pressure solid injection and other devices. Diffusing methods may be classed as (a) sieve method or use of a multi-holed spray nozzle, (b) employment of opposing fuel admission streams and (c) use of a centrifugal disintegrator such as shown in the headpiece of this article.

Disadvantages of the air-injection system are limited principally to the three-stage air compressor and to the cost, complication and danger of the high-pressure air system required. The advantage of the solid-injection system is particularly noticeable for small engines where the cost of air injection would be prohibitive because of the cost and the lack of care usually given those units. Leaky fuel-check valves will cause air to collect in the fuel lines, finally working back to the fuel measuring pump chamber of the one cylinder and getting into the fuel lines of the other cylinders, causing the engine to stop. Check valves, especially in the air-injection system, should be kept tight.

Avoid Accumulations of Air or Gas in the System

Air or gas should not be permitted to accumulate in spray valves or fuel pipes. If air becomes entrapped, it may be removed easily by giving the fuel pump handle a few sharp strokes by hand. When resistance is felt, this pumping should be stopped so that fuel will not be pumped by this process into the cylinder. Indication of air or gas pocketing is manifested when dripping occurs after spray periods. Sluggish spray indicates presence of dirt under the pump valves.

Fuel Injection Valve Types

Fuel-injection valves may be classified as open and closed. Open type valves are so named because the fuel space is in constant communication with the cylinder, as shown in Fig. 1. Fuel is delivered into the fuel space past the check valve and above the spray nozzle by the fuel pump. When the spray needle valve is opened by its valve gear the blast of high-pressure air blows the fuel into the cylinder. Spray valves of the open type are seldom used today. Closed type valves of the air-injection class deposit fuel at some point between the spray valve seat and the source of the injection air as shown in Fig. 2. The fuel is kept from contact with the air in the working cylinder until the moment of injection.

Some closed type valves are fitted with cones and atomizer plates as shown in Fig. 3. These plates serve to divide the fuel into thin streams permitting good mixture with the high pressure injection air, which forces it into the cylinder through the nozzle plate when the needle valve is opened. A closed type with an inward-opening valve is illustrated in Fig. 4. This shows how readily spray valves may be taken apart, after removal of the valve body from the engine, for cleaning or repair while a spare unit has replaced it in the engine.

Other forms of closed-type valves draw the oil by the injector principle into the current of injection air, thus atomizing and absorbing it as fast as it is drawn up. This form avoids the necessity of having so many perforated disks and it is claimed for this atomizer that

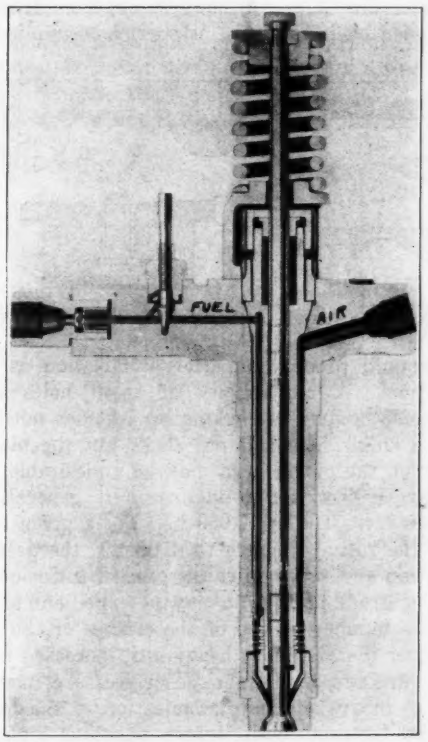


FIG. 4. CLOSED TYPE, INWARD-OPENING INJECTION VALVE WITH CONE-SHAPED SPRAY

fuel leaks into the cylinder are impossible because the fuel cannot enter the cylinder, even with the needle valve open, until it is injected by the injection air.

Spray Nozzle Types

Distribution of fuel in the cylinder is the principal function of a spray nozzle. Air jets assist in creating turbulence. It would appear that better distribution of fuel would be obtained by use of multi-hole nozzles while single jets should create greater turbulence. If, besides the usual radial holes, one small hole is drilled through the lower end as shown at C in Fig. 5, misfiring when operating with intermittent load, can be avoided. Due to the separator effect, fuel alone or fuel with only a small amount of air, will pass through the central hole which produces an ignition jet which is projected into the hottest part of the cylinder and is ignited promptly. The quantity of fuel in the ignition jet may be con-

trolled by the size of the hole and by the depth of the main passage below the usual holes. It should not be greater than necessary as unatomized fuel is slow burning.

Cone-shaped distribution is obtained by means of the type of nozzle shown at E, Fig. 5, also in the headpiece of this article. Sprays with variable orifices are illustrated in Fig. 6. Two of these, A and C, distribute the fuel in a hollow spray similar to that formed by valve E, Fig. 5. Spray valve C establishes turbulence by the annular curved surface of the valve face. Centrifugal disintegration is created by the helical grooves shown at A, Fig. 6.

Spray Orifices

Greater kinetic energy may be expected from a single rounded orifice and if this energy be applied to the

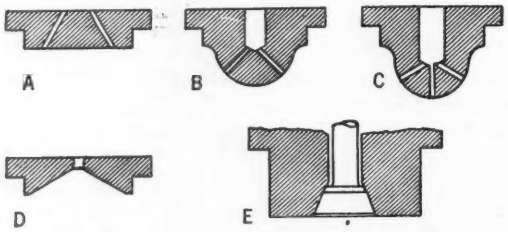


FIG. 5. CONSTANT ORIFICE SPRAY NOZZLE TYPES

jet, it should produce superior atomization as well as penetration. A multiplicity of small holes may be troublesome because of choking up. Under normal conditions a single hole will not choke but the blow-torch effect upon the piston head may be undesirable.

Spray orifices for solid injection generally have diameters from 0.007 to 0.060 in. For a given fuel, the greater the ratio of length to diameter, the greater the penetration and the smaller the area of diffusion. With change of grade of fuel, it may be expedient to change either the number or size of the orifices or the number of atomizer plates. With heavy oils, increased injection air pressure and smaller nozzle orifices are likely to be needed to insure adequate atomization of the fuel than would be required with lighter oils and higher compression pressures within the cylinder and even heating of the fuel to increase its fluidity may be necessary. Injection pressure best adapted for any given condition depends also upon the volume and design of the combustion chamber. Solid injection pressures vary commonly from 1000 to 6000 lb. per sq. in. while some builders are advocating pressures as high as 10,000 lb. The best condition of operation in any case is that which is determined by trial.

While turbulence of combustible mixture is highly desirable, it will be appreciated that smooth admission of the air charge is also important because such admission avoids mixture with the burnt products within the cylinder, hence maintaining a cooler and more dense charge since the hot gases are removed more thoroughly and the cylinder walls better cooled by the scavenging air, also, with much less entrapped burned products, a purer combustible mixture is possible. With this development, which is indicated, reduction in complication, hence simplification of maintenance as well as increased efficiency of the engine will be accomplished.

Smoky Exhaust Indicates Improper Adjustment

Black, smoky exhaust is frequently caused by low-pressure injection air when running at nearly full load under air injection. Increasing the pressure, obviously, overcomes this difficulty. Misfiring of one or more cylinders will cause the others to smoke due to the increased load thrown upon them. Unequal cylinder loading is best determined by comparing indicator cards taken from all cylinders. Dirty spray valves, poor or dirty fuel, accumulation of carbon in the combustion chamber and exhaust manifold and broken or enlarged spray orifices will cause a smoky exhaust. Hard accumulations of carbon may be cleaned from spray orifices by means of straight fluted reamers of proper size. Soaking and washing in kerosene also assists materially.

Proper adjustment or replacement of parts and removal of dirt from the fuel before it reaches the spray valve, will overcome these difficulties. Increasingly, manufacturers are adopting the practice of placing strainers in the fuel line system just ahead of the fuel-injection valve and more and more are centrifugal machines used to remove dirt accumulations from fuel.

Insufficient combustion air is another cause of smoky exhaust. This is usually caused by too great roller clearance, causing the air inlet valve to open late and closely early. In the case of two-cycle engines, low scavenging air pressure will cause the same effect. It is better to watch the exhaust of each cylinder than to watch, simply, the end of the exhaust pipe. For this purpose there should be a peep hole, in each exhaust

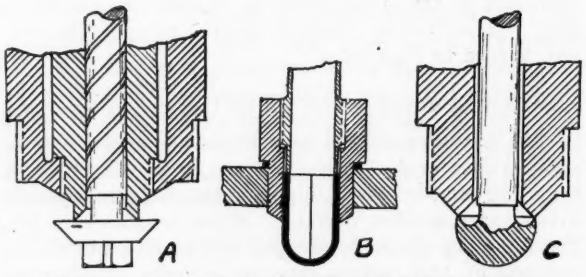


FIG. 6. VARIABLE ORIFICE SPRAY NOZZLE TYPES

connection, as close to the cylinder as possible. If these holes have not been provided by the builder it is advisable for the operator to put them in. Plugs are preferable to valves for closing these holes.

Instruments Indicate Improper Valve Operation

Careful attention should be given to all parts of the fuel-injection valve. At all times, valve stems must work freely in the stuffing box because, if they happen to stick open, fuel is sprayed into the cylinder as fast as it is delivered to the valve by the fuel measuring pump, causing pre-ignition and high temperatures and pressures in the cylinder, which may throw dangerous loads upon the various engine parts. A little kerosene, poured on a sticky stem will often free it but if it does not respond readily to this treatment, the engine should be stopped and the valve given thorough examination and attention. Proper equipment with indicating and recording instruments, guards against serious trouble from these sources.

Tests for Tightness

Tightness of spray-check valves can usually be tested on a running engine by loosening the discharge pipe connection at the fuel pump after the pump handle has been pulled out to the stop position. If any oil comes out, there is a leak past the check valve, hence it should be cleaned, reground or replaced. If a vent cock has been installed in the fuel delivery line, tightness of the fuel-check valves may be checked by opening this cock which will relieve the pressure in the air lines but will leave the valve casing charged with air. If, then, the union in the line is slacked off, any leak will be manifested at once. Or, after a time, the valve may be opened with a bar. If air is heard to blow into the cylinder, it may be assumed that the check is tight. Care must be taken when using a bar, not to damage the valve. Spray valve testers are furnished frequently with the engine and may be connected to the air starting tank as shown in Fig. 7.

To test the spraying action, the complete spray valve should be removed from the engine, connected to the fuel pipe and the pump worked quickly by hand. The spray should break into a perfect mist directly after leaving the nozzle and should be sharp and clean without suffering any drip after completion of the pump stroke. Drip, after the spray indicates that air or gas is pocketed in the fuel pipe or too weak a spring is under the spray check valve. A sluggish spray indicates that there is dirt under the pump valves or overflow valve.

Repair Valves Before Damage Is Great

Attention should be given to fuel valves before they begin to leak, therefore, periodical inspection is important. Reconditioning a near-leaky valve usually requires little time, while refacing a seat that has become badly scored consumes considerable time. When fuel escapes past a needle valve during the compression stroke, the pressure in the cylinder may rise several hundred pounds above normal and can easily exceed that of the injection air. When the needle valve is opened under this condition, instead of fuel and air moving toward the interior of the cylinder, they are forced by the excessive pressure to go backwards into the atomizer. Ignition under these circumstances may take place around the seat of the needle valve and among the atomizer plates at intense pressure, producing a temperature which may be high enough to fuse the metal of these parts.

Such flare-backs, in extreme cases, may extend back into the injection-air lines if the air checks are in poor condition or if no air checks have been provided. If fuel has been pumped back into the air lines while priming, there is a possibility of an explosion, under this condition, when the engine is started. Carbon deposit in fuel valves is an evidence, usually, of flare-back action.

Too Frequent Reaming Destroys Seat

Minor scores can be removed by grinding but if the seat is rough, reaming is necessary. Too frequent reaming results in burying the tip of the needle valve as shown in Fig. 8, thus preventing it from opening until it is raised above the bottom of the cone-shaped seat indicated by the dotted line in the figure. Such a seat must be repaired by reaming the portion above the valve seat or it should be replaced if it is removable. Result of excessive wear on a needle valve is illustrated in Fig. 9. A seat so badly worn should be replaced. Reaming or grinding of a valve seat should not be done to such an extent as to cause the valve tip to protrude and strike the flame plate. Where valve wear is excessive, it is wise to examine the fuel oil for impurities and remove them by centrifuging or filtering the fuel. As in the case of engine valves, only a narrow surface is necessary to secure tightness. A mere threadlike surface, $\frac{1}{32}$ in. wide will seal a needle valve. Grinding should be accomplished in a manner similar to that described in Part IX, February 15 issue.

Corrosion Prevented by Removal of Water

Corrosion of the spindle or other part of the valve is sometimes attributed to impurities in the fuel but if this were true, the fuel pumps likewise would become corroded which is not the case. Water carried by the injection air is a frequent cause of corrosion hence it is prevented by the removal of the water from the air.

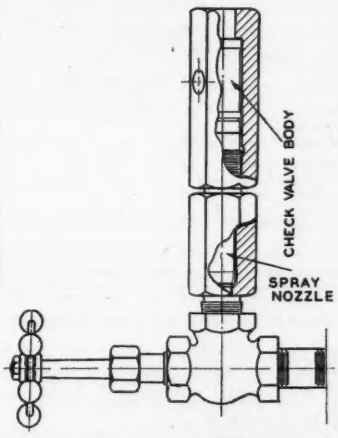


FIG. 7. SPRAY VALVE TESTER CONNECTED TO AIR- STARTING TANK

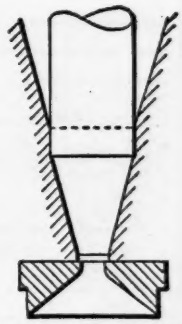


FIG. 8. EFFECT OF TOO FREQUENT REAMING OF VALVE SEAT

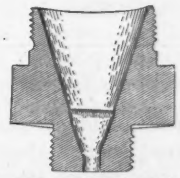


FIG. 9. RESULT OF EXCESSIVE WEAR ON NEEDLE VALVE SEAT

Replacing a fuel valve in a cylinder should be done with care to secure a tight joint between the valve body and the cylinder. A small leak may result in carbon deposit which would make subsequent removal of the valve difficult.

Too much end play of shafting is likely to cause trouble with belt and pulley alinement but a slight amount is essential for best operation of bearings. Shaft collars should be used to limit end play unless pulley hubs come close to the ends of bearings so as to serve the purpose.

Obsolete boilers, prime movers, auxiliaries and power plant operating methods often take the profit out of a prosperous business.

Maintenance Methods for Electrical Equipment

SYSTEMATIC MAINTENANCE SCHEDULE INSURES AGAINST SHUTDOWNS AND ANTICIPATES REPAIR WORK. BY E. L. RICHARDS

IT USED TO BE quite the custom for persons to wait until they were definitely or rather seriously ill before calling a doctor. Nowadays most people realize that it pays in improved health and reduced doctor bills to visit the doctor periodically even when in health to forestall serious illness. Each year we learn more and more the truth of the age-old saying, "an ounce of prevention is worth a pound of cure."

There are many plant electricians, however, who seemingly fail to realize that this applies equally well to the maintenance of electrical machines. There are

MAINTENANCE RECORD OF 3 ph. Slipring Mot. Serial # 172173
Name of Manufacturer C.E.S. H.P. 20 R.P.M. 1140
Volts 440 Amperes 26 Cycles 60 Date Nov. 1st 1929
AIR-GAP

1 Completed	13 Tight and loose sleeve	25 Does not apply	
2 All items OK	14 All tight + brush	26 None. Runs very quiet	
3 All items OK	15 Does not apply	27 No local heating	
4 OK	16 OK	28 5 seconds	
5 Drained + refilled	17 OK At diagram record	29 All tight	
6 None	18 OK	30 450,000 ohms	
7 OK	19 None	31	
8 OK	20 All rings clean and in good condition	32	
9 OK	21 Does not apply	33	
10 Both Normal	22 Ground and open circuit stuck in holder	34	
11 OK	23 Lug + brush lead against brush with long brush lead	35	
12 Normal	24 OK	36	

Inspectors Name John Doe

FIG. 1. TYPICAL MAINTENANCE RECORD FOR MOTORS

still numerous places where the policy seems to be "let good enough alone" and wait until equipment fails entirely before attempting to repair it.

Electrical machines generally show symptoms of their common troubles for some time before they fail, and these symptoms should be just as noticeable to the experienced maintenance electrician as are the patient's symptoms of illness to a good doctor.

In fact, the maintenance man could well consider his position as that of doctor to the plant electrical equipment and if he would value the services of a doctor who could keep him well by occasional inspection and preventive treatment, then let him remember that his employer will value his services much more if he can keep the electrical equipment "well" and properly functioning at all times, by the same methods of regular inspection and speedy correction of small faults before they result in shut-downs and costly repairs.

In the plant where electrical maintenance is intelligently handled according to a definite plan of inspection and repair, the work becomes easier, more interesting, and much more satisfactory to plant owners, and the maintenance man can really feel that he is running the job. In plants where no system is followed and repairs are made only when breakdowns and emergencies occur, maintenance work becomes a drudge and a rush from one costly repair job to another, and actually the job runs the man.

The writer has known of instances where a maintenance crew of eight or ten men, working with no system and constantly rushed and in "hot water" with the chief engineer or plant manager, has been changed over by the use of a well planned maintenance program, to a well ordered crew of four or five men, working less overtime, and with time to think and use their heads to avoid many troubles. The men thus released can generally be used for other work; or if not, they can be dropped from the payroll and given an opportunity to promote the same plan somewhere else.

In the small plant, the individual maintenance man can use the same plan to make his work easier and, at the same time, make his services more valuable and satisfactory to his employer.

IMPORTANCE OF INSPECTION SCHEDULE AND RECORDS

One of the most important helps in modernizing and systematizing electrical maintenance in any plant is a definite inspection schedule for all motors, controllers and other important electrical equipment.

These regular systematic inspections help to catch many small troubles before they grow to be large ones. Then if maintenance records and test data are kept on all important machines, occasional reviewing of these records will often show up approaching troubles far enough in advance so that the machine can be shut down and repaired during some holiday or period when the plant is not in operation, instead of at a time when it is very badly needed.

Inspection periods may vary from daily inspection of very important and expensive machinery, to weekly or monthly inspection of less important equipment. In some cases, certain devices may not need to be inspected more often than once every three to six months. This depends on the nature of the equipment and the service conditions under which it is working. Experience in various plants will soon show how frequent inspection of various devices should be. It is much better to inspect them too frequently at first than not often enough. If certain devices have very few faults occurring and require little service, the inspection schedule for them can easily be adjusted accordingly.

It is well to remember, however, that the small amount of time required to adjust and touch up small defects will generally prevent a much greater amount of time being spent in more disagreeable work if these points are neglected.

As alternating current motors are so commonly used in industrial plants, we will consider some of the features of their maintenance first and later on take up those for controllers, d.c. machines and other electrical equipment.

The following list of items to be checked in connection with the inspection of a.c. motors is given as a suggestion, or an example of inspection sheets or schedules which can be developed to fit the needs of various plants.

1. Clean off motor, particularly all ventilation ducts and windings.
2. Check condition of stator windings.
   (a) General condition of insulation.
   (b) For oil soaked coils.
   (c) For hardened oil or grease on coils.
   (d) For bare or skinned conductors.
   (e) For poor taping.
   (f) For clearance between coils and rotating parts.
3. Check condition of rotor windings (on machines with wound rotors). Check items a, b, c, d, e and f as above.
4. Check bearing oil level.
5. Check condition of bearing oil.
6. Check for possible oil leakage.
7. Check to see that oil rings move freely.
8. Check condition of oil well covers and drains.
9. Check condition of bearing dust seals if used.
10. Check any tendency of one bearing to heat more than the other.
11. Check tightness of bearing retaining screw.
12. Check amount of end play of shaft.
13. Check tightness and condition of gear or pulley.
14. Check tightness of lugs and connections at motor leads.
15. Check to see that squirrel cage rotor bars are tight in slots and at end ring connections.
16. Check air gap or clearance between stator core and rotor.
17. Check condition of ground wire and ground connections.
18. Check tightness of motor on foundation.
19. Check for any tendency of motor to vibrate while running.
20. Check condition of slip rings if used.
21. Check condition of centrifugal switch on fractional horsepower machines.
22. Check condition of brushes and holders (on slip ring or repulsion-induction motors).
23. Check brush tension, brush setting, and see that brush connections are tight.
24. Check slant or angle of brushes with respect to direction of rotation.
25. Check condition and free operation of short-circuiting devices when used.
26. Investigate any unusual sounds or noises when motor is running.
27. Investigate any local heating of certain coils or groups of coils.
28. Note time required for motor to accelerate when starting.
29. Tighten all mechanical parts, bolts, nuts, screws, etc.
30. Test insulation-resistance of the machine with a megger or Wheatstone bridge.

When reading over a list such as just given, one may at first think it an endless task to check all of these items, but in actual practice an experienced man, once he is familiar with the list, will check many of these items at a glance or a touch and even catch several of them all together in a few seconds of time.

In many cases, detailed inspection such as outlined in the preceding list may be made only at intervals of once a month or less often, while more frequent daily or weekly inspection is made of a few more important items.

The most important of these items in connection with a.c. motors are the following: Clean windings, proper temperature of windings, open air ducts and ventilating ports, condition of insulation on windings, bearing temperatures, condition of bearing oil, free movement of oil rings, etc.

Maintenance Record Forms

A simple form of maintenance record for individual motors is shown in Fig. 1. If a form of this type is used for each inspection of individual motors, particularly on those of larger sizes, it helps to prevent overlooking certain items of importance and greatly simplifies the keeping of intelligent maintenance records.

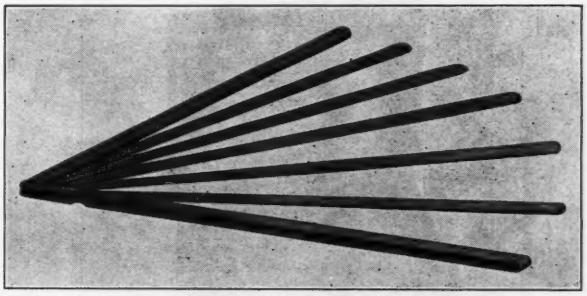


FIG. 2. AIR GAP GAGE USED TO DETERMINE ROTOR CLEARANCES

Numbers shown on this form refer to the items given in the preceding motor inspection list. These items to be checked can be designated by the numbers, or can be briefly printed on the forms in case the maintenance men are not sufficiently familiar with the schedule to recognize the items by numbers.

The form shown here has spaces at the top for the description and serial number which identify the machine, so that its monthly maintenance records can be filed together and accurately kept, no matter to what part of the plant the machine may be moved.

Note the space provided in the upper right-hand corner of this form, for marking down the air gap readings. Four of these readings should be taken around the inside of the stator core in the positions shown at the top, bottom, right and left sides of the rotor.

Air gap readings are taken with an air gap gage, which is provided with several long narrow steel blades or leaves, similar to those of a machinist's feeler gage. A gage of this type is shown in Fig. 2.

Many shops and plants do not have one of these gages on hand and a great many maintenance men can be found who are not even familiar with its purpose or use. Air gap gages can be obtained from certain motor manufacturers for about $2.00 each.

Air gap readings should, of course, always be taken when the motor is standing idle. The reading is taken from the largest gage, which can be pushed in between

the rotor and stator in the same direction as the slots of the machine run.

Large air gaps may require measuring with two or more blades together, in which case the reading is the sum of the numbers on the blades used to fill the gap.

As an example of the usefulness of these inspection records, suppose that upon going over the monthly records of a certain machine and noting the air gap readings it is found that about every six months the air gap at the bottom of the rotor is decreasing 0.005 in. and the gap at the top increasing the same amount. This indicates rapid wearing of the bearings which allows the shaft and rotor to drop and the lower side of the rotor to come closer to the bottom of the stator core. From the rate of wear shown by this record, it is easy to determine just about how much longer the machine will run before the rotor starts rubbing on the stator core.

This enables the maintenance man or crew to plan their work and set a certain time for repairing the bearings at some period when the motor is idle and before the bearing wear causes a forced shut-down or serious trouble.

FIG. 3. MEGGER TEST SET FOR MEASURING INSULATION RESISTANCE

As another example of the value of records, suppose it is found and recorded that on a certain motor the oil level is very low at each inspection although no definite trace of leakage can be found. This would indicate positively that the bearings were leaking a small amount of oil or using it up quite rapidly in some manner, possibly by siphoning action due to strong air currents through open type bearings. The record would show that the bearings should be refilled more often to avoid danger of overheating.

Sometimes a record of this sort will stimulate the inspector to make a very close check over the entire bearing housing, which may disclose an almost invisible crack, or a tiny sand hole in the casting. Cracks of this nature can be repaired by welding or brazing. Sandholes can be closed in the same manner, or by drilling them out, tapping the hole and tightly inserting a threaded plug. Sometimes small sand holes can be closed by tapping them with a round headed hammer.

Suppose, in another case, the inspection record shows a certain section of the stator winding slightly warmer than the balance of the winding. If each successive record shows this heating to be continuing in the same spot and apparently somewhat increased each time, it would indicate defective insulation or a partial short or ground in the windings at this point.

The machine should then be shut down for reinsulation or repair of that section of the winding, as soon as it can be done without interfering with production in the plant. If such repairs are not made in time, one can be practically certain that these coils will eventually burn out and cause the machine to fail completely and perhaps require a much more expensive repair.

Probably one of the most common and valuable indications given by maintenance records of this kind is that of gradual deterioration or failing of the insulation.

Suppose that the Megger test record of one month shows the insulation-resistance of a certain machine to be 1,250,000 ohms, 1,150,000 ohms three months later and 1,000,000 ohms six months later. These records would indicate that the insulation of the machine is rapidly failing as the result of moisture, oil soaking, or old age and would mean that the machine should be dried out, have the oil washed out of the windings; or if neither of these faults is to blame, the winding would need to be reinsulated or replaced as soon as the machine could be taken out of service for a sufficient period.

If the machine has been operating in a damp atmosphere and the windings are found to have absorbed moisture, they can be dried out by building a temporary jacket of sheet metal or asbestos around the machine and passing dry, heated air through it for a period of several hours or days, according to the size of the machine.

In emergencies this drying process may even be performed while the machine is in operation, provided it is not running under heavy load and if its temperature is carefully watched to see that it does not overheat.

If the windings are oil soaked, they can be washed out with a mixture of gasoline and carbon-tetra-chloride. The carbon-tetra-chloride is added to the gasoline in amounts from 25 to 50 per cent to reduce the fire hazard. The windings should be allowed to dry thoroughly before the machine is put back into service after cleaning by this method.

A Megger can be used conveniently for testing the insulation resistance from time to time during the drying process in order to tell when practically all of the moisture has been removed.

In case of failure of the insulation only in certain spots on the stator coils, this can often be repaired by raising these few coils from the slots, retaping them and renewing the slot insulation.

Troublesome grounds or shorts can often be cleared in this manner and the machine placed back in service for many more months or years, if the remaining insulation is in good condition.

Well kept maintenance records also show what spare parts should be kept on hand for making immediate repairs and what spare machines or equipment should be carried for emergency replacements until defective units can be repaired.

New Oil Blast Circuit Breaker is Effective*

A New Type of Circuit Breaker in which Arc Products Are Swept Away by Scavenging Action of an Oil Blast. By D. C. Prince and W. F. Skeats†

HAVING BEEN USED for over 35 yr. as a circuit interrupter for alternating-current circuits, the oil breaker is still the most practical and effective device for the purpose so far developed. In recent years, much study has been given to the determination of the fundamental characteristics of the arc in oil as encountered in oil circuit breakers. Much study has been given the question of arc length and arc duration and the amount of gas formed by an arc in oil.

Recently an excellent analysis of oil circuit breaker phenomena has been presented in which the qualitative factors governing deionization rates in arcs have been explained. The principle of confining the arc and maintaining a supply of oil in its immediate vicinity has been

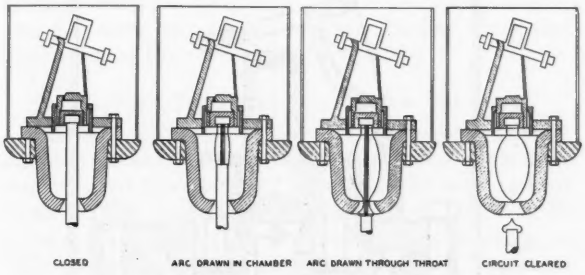


FIG. 1. DIAGRAM SHOWING THE OPERATION OF EXPLOSION CHAMBERS

confirmed, although the means suggested differ considerably in operation.

The deionization processes suggested, however, operate vigorously throughout the current cycle, requiring for an arc of given length, high voltage and energy dissipation and causing, therefore, a rapid evolution of gas. This is unavoidable where effective deionization at the current zero must be secured in a fairly homogeneous arc path. But the arc path at the time of rupture need not be homogeneous and it is the purpose of this paper to describe a process operating along entirely different lines.

At the time of rupture for existing circuit breakers, the arc path has an effective dielectric strength of from about 2500 v. per in. in plain-break circuit breakers up to 10,000 v. for the Deion grid breaker and as high as 15,000 v. for standard explosion-chamber circuit breakers. Clean oil has a dielectric strength of over 200,000 v. per in., with a strength of under impulse over 600,000 v. per in. The introduction of any considerable amount of solid oil into the gap at the current zero, therefore, holds possibilities of great improvement over other methods of interruption.

Figure 1 shows a standard high-speed explosion-chamber circuit breaker in four positions. In the first diagram the breaker is shown in the closed position. In the second, the contacts have separated and a small arc has been drawn which has decomposed enough oil to place the remaining oil in the explosion chamber under considerable pressure. In the third diagram, the moving contacts have reached the explosion-chamber throat and oil is being crowded in upon the arc in the throat. In the fourth diagram the oil has divided the gas bubble into two parts, interposing a solid wall between them, and thus effectively opened the circuit.

As the gas bubble expands, driving the oil through the throat of the explosion chamber, the pressure varies

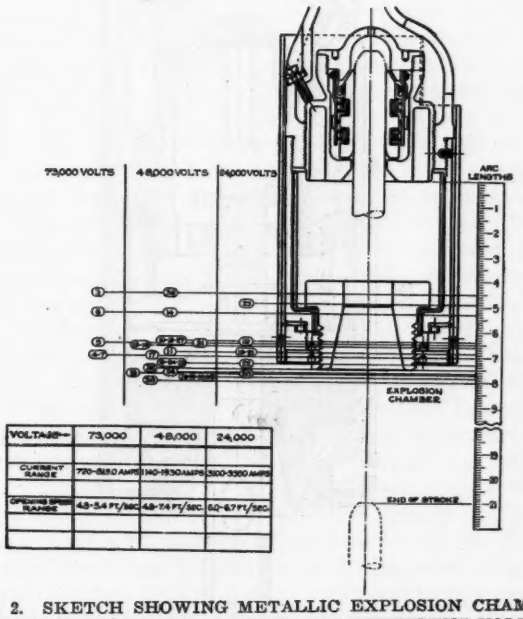


FIG. 2. SKETCH SHOWING METALLIC EXPLOSION CHAMBER AND VARIOUS ARC LENGTHS FOR DIFFERENT VOLTAGES. CIRCLED NUMBERS ARE VARIOUS TEST NUMBERS

from hundreds of pounds in the large part of the volume of the explosion chamber to a very low value actually in the throat. That is, the potential energy of pressure has been converted into kinetic energy of velocity. At the same time, since the pressure is low in the throat, the oil can very easily rush into this space so as to cut the arc in two.

That this is actually what happens is proved very well by Fig. 2 in which, for a large number of tests at widely different voltages, the arc is uniformly extinguished while the contact tip is passing through the explosion-chamber throat.

In order to make this action even more sure and positive the form of explosion chamber shown in Fig. 3 has been developed. It contains an upper butt contact A, a floating contact B, and a hollow contact C. In the closed position current is carried by these three members firmly pressed together. When the breaker is tripped, the floating and hollow contacts, B and C, start down,

*An abstract of paper presented at the winter meeting of the A.I.E.E., New York, January 26-30.
†Both of the General Electric Co.

driven by the opening springs, thus drawing a short arc between A and B. This arc forms gas and places the oil in the explosion chamber under considerable pressure for which there is very little relief until the floating contact reaches its stop. The secondary break then occurs between contact B and C and a second arc is drawn between these contacts. But as the oil glides through the passageway in the contact rod, this arc is carried before it and exists alongside it without mixing, and hence with a minimum of loss throughout the current cycle. Then, as soon as the current zero is reached, the arc products are displaced by a smooth flowing wall of solid oil, the dielectric strength of which has not been impaired by carbonization or entrained ionized gas.

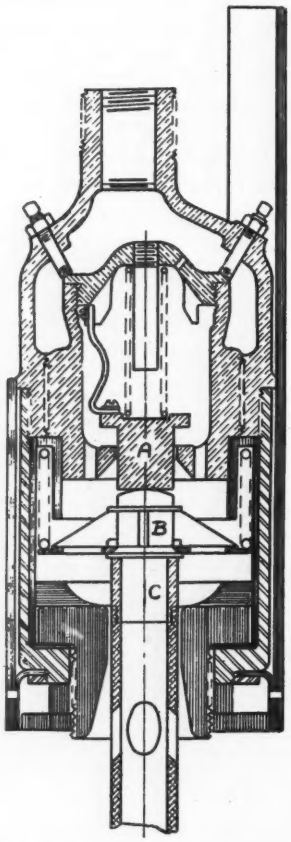


FIG. 3. SPECIAL EXPLOSION CHAMBER

Several beneficial effects are obtained by the use of this modification. In the first place, the necessary arc length at generator voltages is reduced from something slightly in excess of the inside length of the explosion chamber to a little over an inch per break. This shorter arc length can be more rapidly established with a given contact speed, which is a decided advantage where it is particularly important to cut down the duration of short circuit. Furthermore, both on account of the shortness of the arc and its brief duration, the energy which it dissipates is much reduced. The importance of reducing the energy from the point of view of (1) keeping down the mechanical stresses and oil deterioration resulting from a given interruption, (2) increasing the interrupting capacity of a structure of given size, and (3) minimizing the demonstration accompanying an interruption, has been brought out by other investigators as well as the authors. In addition, the shorter arc duration results in less burning and longer life of the contact parts and of the oil. Also, both arcs are quite effectively kept away from insulating material so that burning insulating parts is reduced. These two latter effects operate to cut down inspection and replacement requirements. Finally, the oil is more effectively directed into the second gap, so that the current range over which the chamber operates effectively is increased.

Over 250 tests have been made at currents from 900 to 25,600 amp. at 13,200 v. and up to 56,400 amp. at lower voltages. Above 5000 amp. the arc is uniformly extinguished at the first current zero occurring after the secondary contacts have been separated by as much as an inch and in many cases the arc has been extinguished with a contact separation of but a quarter of an inch.

The need for high speed of interruption is fully as urgent at transmission voltages as at generator voltages.

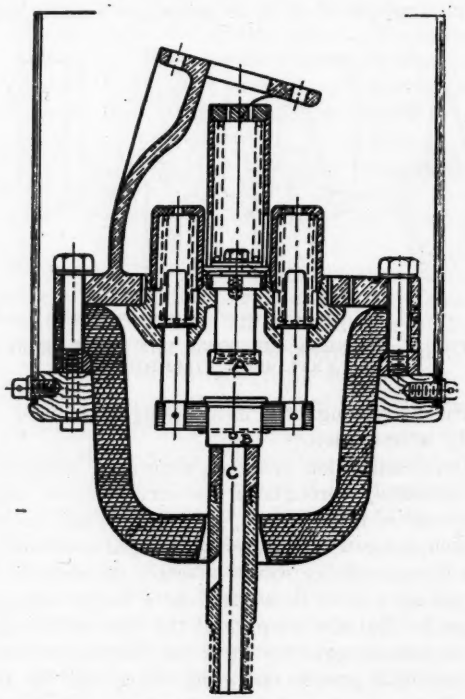


FIG. 4. OIL BLAST EXPLOSION CHAMBER FOR 110-KV. OIL CIRCUIT BREAKER

Accordingly, a somewhat larger explosion chamber was modified to correspond to Fig. 3.

At 110 kv., however, it was found more desirable to substitute molded explosion chambers for the steel ones used at the lower voltages. The detailed arrangement of these chambers is shown in Fig. 4.

On July 4 the explosion-chamber arrangement just described was installed in a three-phase oil circuit breaker at the Philo plant of the American Gas & Electric Co. The breaker rating was as follows: FHKO-139-60B, 132,000 v., 600 amp. This oil circuit breaker interrupted a large number of short circuits. The results of these tests have been calculated and plotted in terms of calculated recovery rates for the systems at-

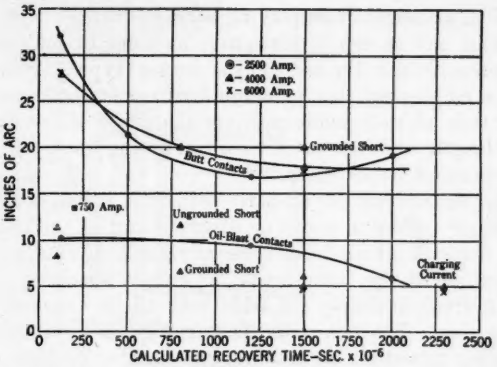


FIG. 5. TESTS AT PHILO, ON THE FHKO-139-60B. 132 KV.; 600-AMP. BREAKER SHOWING THE MAXIMUM ARC LENGTH VS. RECOVERY TIME.

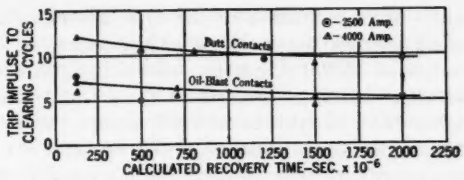


FIG. 5. TESTS AT PHILO, ON THE FHKO-139-60B. 132 KV., 132 KV.; 600-AMP. BREAKER SHOWING THE DURATION OF SHORT CIRCUIT VS. RECOVERY TIME

tached, as shown in Fig. 5 and 6. In Fig. 5 is shown a comparison of the arc lengths for the butt contact explosion chamber and the oil-blast explosion chamber. The arc length with the oil-blast is much less than with the butt contacts. Figure 6 shows the actual overall time for these two-circuit breakers figured from the application of the current to the trip coil.

Laboratory Tests and Field Tests Compared

The gain in the case of the oil-blast contacts is more impressive when it is remembered that the mechanical time required to separate the contact is the same in both cases. Of the single-phase laboratory tests, those at 88 kv. are probably the most comparable with those at Philo, which were made with the same explosion chambers (Fig. 5). The maximum arc lengths were about the same, although the recovery time of the test transformers is only 60 per cent of the shortest time in the Philo tests. An especially reassuring feature of these tests is that the factory testing plant appears to stress the circuit breaker as severely as a large central station connection providing two and one-half times the short circuit energy.

During the tests it has been found that the circuit has, in many cases, been successfully opened with chamber pressures less than those calculated above as theoretically necessary. This is explained by a more complete analysis of the oil flow during the arcing period.

Old Theories Do Not Have To Be Proved or Disproved

Figure 7 shows a series of drawings representing the locations of arcs, gas and contacts during an operation of the breaker. Figure 7A shows the contacts in the closed position. In Fig. 7B the upper contacts have parted, establishing the pressure-generating arc. The lower contacts have parted in Fig. 7C and the current is still considerable, giving a fat arc which is, however, beginning to be carried down the contact tube, which has been freed of oil, and gas is commencing to escape from the vent holes. As the arc dwindles with the cyclic decay in current, the oil moves radially inward along an area many times larger than the bore of the contact tube. At the current zero, Fig. 7D, the velocity of gas moving downward into the tube becomes many times the velocity of the inward-flowing oil. In effect the rate at which solid oil dielectric replaces ionized gas is the velocity with which the gas can go through the bore of the contact rod. The gas passes through the contact tube at the velocity of sound, 2300 ft. per sec. in oil circuit breaker gas at ordinary temperatures, while at arc temperatures it probably exceeds 10,000 ft. per sec., which accounts for the extraordinary rate at which the space once occupied by the arc recovers its dielectric strength.

In old types of plain-break oil circuit breakers, the fact that the voltage divided by arc length gave values of approximately 2500 v. per in., or approximately one per cent of the strength of the oil, has frequently caused

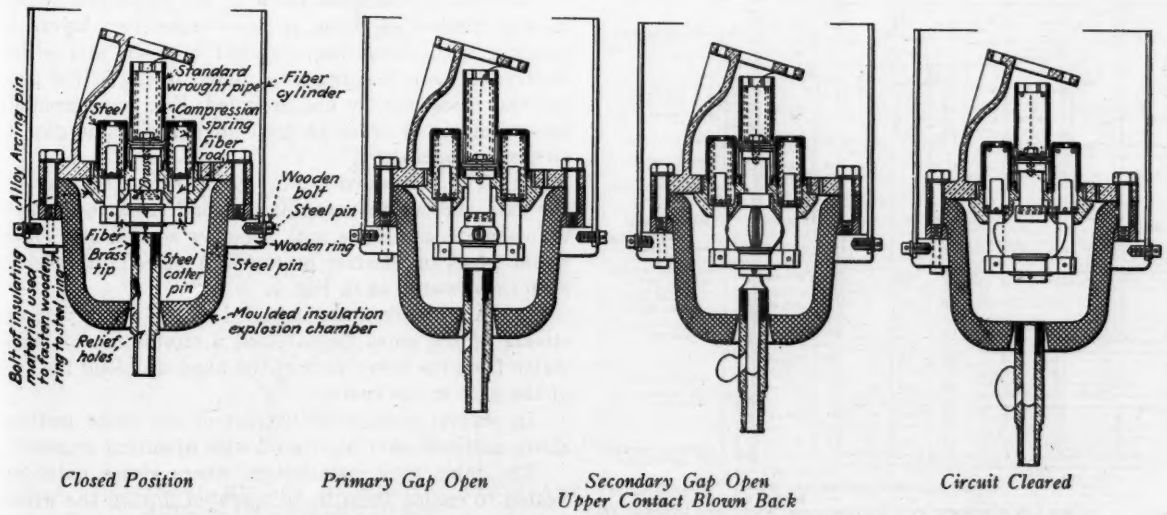


FIG. 7. DIAGRAM SHOWING LOCATIONS OF ARCS AND GAS IN OIL BLAST EXPLOSION CHAMBER

comment. With a breaker of the type described above, the voltage across the working gap reaches, in actual test, values of 44,000 v. per in., which is quite comparable with the ultimate strength of the oil and considerably higher than should be allowed across the internal dielectric in the open position of the breaker.

Since there has been no need for mixing oil and arc in the main gap, the parts are so made as to permit a smooth flow. The arc then burns in quiet gas with a minimum of arc drop. It decomposes a minimum amount of oil and serves as an excellent medium for carrying the current with a minimum loss until the arrival of current zero.

The arc energies in the tests have been too low to measure satisfactorily from oscillograms. Data are being collected by means of a ballistic galvanometer by which it is hoped that more refined comparisons of the circuit-breaker behavior can be made in the future.

The principle of employing solid oil instead of mixed oil and gas as the interrupting medium in oil circuit breakers is not limited to the larger types. Smaller types employing this principle are under development and tests already made indicate that large decreases in arc length and increases in interrupting capacity will be obtained in all cases.

In developing the oil-blast principle, it has not been necessary either to prove or disprove any of the numerous theories which have been advanced to explain the operation of the plain-break oil circuit breakers. The plain break is simply set aside with all its vagaries and mysteries. The arc with its varying gas composition, varying pressure, uncertain temperature, varying conductivity, unknown state of ionization, etc., is merely swept away and its place taken by solid oil of known and high dielectric strength, something that is understood and can be tested with certainty by any laboratory.

Combating Ice Formation at Sluice Gates

METHODS USED AT SEVERAL HYDROELECTRIC PLANTS TO AID WINTER OPERATION, TOGETHER WITH DATA ON POWER REQUIRED FOR HEATING GATES*

WITH THE INFORMATION obtained after corresponding with practically all the power companies operating hydroelectric plants in Canada and the northern part of the United States, the following conclusions have been drawn by the N.E.L.A. Hydraulic Power Committee with regard to the practice of combating ice and operating in cold climates.

Practically every large hydroelectric development requires some means of bypassing large quantities of waste water. Many plants have adopted sluice gates of the Stoney type, from 30 to 50 ft. wide and from 15 to 25 ft. high.

*From a report on Ice Problems in Hydroelectric Plants by the Hydraulic Power Committee, N.E.L.A.

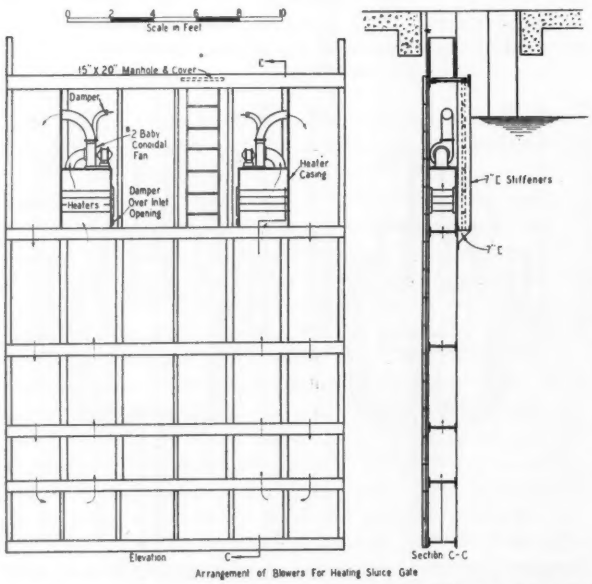


FIG. 1. ARRANGEMENT OF BLOWERS AND HEATERS IN 16 BY 20-FT. SLUICE GATE AT SMOOTH ROCK FALLS

In a normal winter, when ice forms on quiet water to a depth of 2 to 3 ft., such gates, if not insulated or heated, would freeze in solidly and a wall of ice almost as thick as the surface ice would form upstream and across the full face of the gate. Cases have occurred when, with the warm sun in the spring, the gates have thawed clear of the surface ice and the wall which formed upstream of the skin plates, so that the gates could be lifted but the ice was still so thick and strong that it held back the water completely by its own strength. Cases have occurred where the thrust of the ice has caused serious damage and buckling of the skin plate of the gate.

Three different methods of keeping sluice gates free were described in the various reports submitted by the power companies, which may be outlined briefly as follows:

(a) The downstream faces of the gates are housed in with timber sheeting, in some cases two layers of sheeting with insulating material between and either electric or steam heating coils placed inside of the gate. In some cases blowers are provided, Fig. 1, to circulate the warm air in order to keep all parts of the gate at an even temperature.

(b) The embedded parts, which form the seat for the gate and which transmit the load from the gate to the concrete, are made with a hollow section and either steam pipes or electric heaters are placed in them to keep them warm, as in Fig. 2.

(c) Air bubblers are installed in the water just upstream of the gates to maintain a circulation of warm water from the lower part of the pond up along the face of the gate to the surface.

In several cases combinations of the three methods above outlined have been used with apparent success.

The table lists installations where sluice gates are heated to enable them to be operated during the winter periods. The overall dimensions of the gates are given,

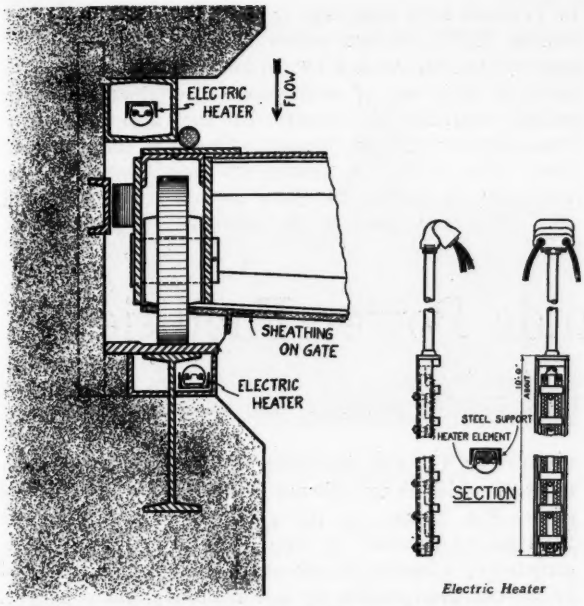


FIG. 2. DETAILS OF HOLLOW EMBEDDED PARTS AND HEATERS FOR SLUICE GATES

together with details and total energy required for heating. In the last column is tabulated the energy in watts required per square foot of gate area, as indicated by reports of the different companies.

Analysis of the reports submitted showed the following:

(a) In order to keep sluice gates free for winter operation, it is absolutely necessary that they be well housed and insulated on the downstream faee, as, without this protection, the heat required to keep them in operating condition is great.

(b) With properly housed gates and with a moderate degree of heat applied inside the gates, it is possible to operate gates throughout the winter with little additional attention.

(c) Hollow embedded parts in which heating elements are placed greatly facilitate maintaining gates in operating condition throughout the cold weather. These heaters are especially useful in preventing ice from forming on the bedded parts when the gate is raised entirely out of the water, also for preventing accumulations of ice just downstream due to leakage water or spray rising from water discharging under the gate.

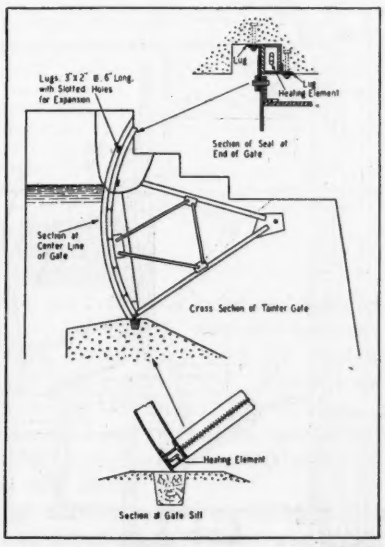

Lugs 3"x2" @ 6' Long, with Slotted Holes for Expansion
Lug
Lug
Heating Element
Section of Seal at End of Gate
Section at Center Line of Gate
Cross Section of Tainter Gate
Heating Element
Section at Gate Sill

FIG. 3. SUGGESTED METHOD OF HEATING SEALS AND BOTTOM OF TAINTER GATES

(d) With a carefully designed air circulating system for maintaining uniform temperatures throughout the gate, either with blowers or a system of chimneys using natural draft, a properly housed gate may be kept in operating condition with 16.5 w. per sq. ft. of gate area, or 18 kw. total input for a 50 by 22-ft. gate. Temperatures inside gate of this size equipped with electric heaters were well over 32 deg. F. in all parts of the gate.

(e) A bubbler system alone without heat inside the gate would not keep a gate in operating condition, as the sill and seals would freeze and prevent operation.

(f) Air circulation within the gate is absolutely essential if economy of heat is desired.

The heater units for bedded parts which have been found most satisfactory by the Dominion Bridge Co. are shown in Fig. 2. These consist of spirals of Nicrome wire about 10 ft. long supported on porcelain insulators mounted on a structural channel to form a reasonably rigid unit for insertion into the duct. These are arranged with the conduit extending above the top of the duct through a combined locking device and stuffing-box, so that the 10 ft. length of heater may be raised or lowered in the duct depending on the water level.

Heaters for the interior of the gate may be of any of the standard space heaters found on the market. Good results have been obtained with those having about 1 in. wide nicrome ribbon for heating element, the element being mounted on a rigid frame and enclosed in

TABLE OF ENERGY USED BY VARIOUS COMPANIES FOR KEEPING SLUICE GATES FREE OF ICE

NAME OF PLANT AND OWNER	NUMBER OF GATES HEATED	SIZE OF GATE IN FEET	KW OF HEAT USED IN GATE PROPER	KW OF HEAT IN BEDDED PARTS-SEALS	TOTAL KW OF HEAT USED	ENERGY IN WATTS PER SQ. FT. OF GATE	REMARKS
CHELSEA GATINEAU POWER	1	50×19½	35	10	45	46	O.H. OPERATES FREELY IN COLDEST WEATHER
GRAND FALLS NEW BRUNSWICK	3	46×20	—	6	6	6.5	DUCTS IN BEDDED PARTS FILLED WITH OIL. 1.5 K.W. HEAT PER DUCT. O.H. DOWNSTREAM FACE NOT HOUSED.
HEMMINGS FALLS SOUTHERN CANADA POWER CO.	1	50×22	15	—	15	16.5	10 BUBBLERS - 17 C.F. AIR - OPERATES O.K. IN COLDEST WEATHER. ICE FORMS ON BEDDED PARTS WHEN RAISED - BLOWER IN GATE
	3	50×22	15	—	15	16.5	BUBBLERS IN FRONT - NO BLOWER - POOR CIRCULATION - REQUIRES STEAMING BEFORE OPERATION
ISLE MALIGNE DUKE PRICE POWER	1	40×27½	40	—	40	36.3	OPERATION O.K.
MANITOBA POWER MANITOBA	1	50×33	10	2	12	8	THAW WITH STEAM BEFORE OPERATION SPRAY FREEZES ON DOWN STREAM FACE
PAUGAN FALLS GATINEAU POWER	2	50×33	36	16	52	31.5	O.K. - HEATERS DISTRIBUTED IN GATE
	2	25×39	24	16	40	61.5	
SHAWINIGAN FALLS " POWER	2	40×18	25	8	33	46	O.K.
SMOKY FALLS SPRUCE FALLS POWER + PAPER	1	46×27½	36	24	60	47.5	
	3	46×27½	—	—	—	—	STEAM HEATED WITH COILS FROM 1-100 H.P. BOILER AT 80# PRESSURE.
STURGEON FALLS ABITIBI EL. CO.	2	20×15	22	—	22	73	TAINTOR GATES - SURFACE O.K. BUT FREEZE AT SILLS - REQUIRES CHOPPING BEFORE OPERATION - FREE HEATERS IN BED PARTS - FIG. 7
JIM FALLS WISCONSIN		16×12	2	—	2	10.5	5000 K.W.H. PER YEAR. NO DATA ON OPERATION
CONSUMERS POWER MICHIGAN		25×15	—	—	—	—	STEAM HEATED - REQUIRES 15 TONS OF COAL PER GATE PER YEAR - REQUIRES ABOUT 15 BOILER H.P. PER GATE.
BACK RIVER MONTREAL ISLAND POWER	1	40×24	45	16	61	63	HEATERS DISTRIBUTED O.K. IN COLDEST WEATHER
	1	40×24	30	16	46	48	HEATERS CONCENTRATED - POOR CIRCULATION - ICE FORMS ON UPSTREAM FACE NEAR TOP
	3	40×24	30	—	30	31	SEALS FREEZE - ALSO UPSTREAM FACE NEAR TOP - POOR CIRCULATION.
SMOOTH ROCK ABITIBI EL. CO.	1	16×20	30	20	50	156	TWO BLOWERS WITH ⅓ H.P. MOTOR TO MAINTAIN AIR CIRCULATION - SWITCHES TO CUT PART OF HEATERS ON OR OFF - FIG 2.
	1	30×36	36	12	52	47.5	INCLUDES TWO BLOWERS FOR CIRCULATION AND 6 500 W GLOW HEATERS UNDER CURTAIN JUST ABOVE SURFACE ON UPSTREAM SIDE.
BELLOWS FALLS VERMONT	2	115×18	—	8	8	7.7	HEATERS IN BEDDED PARTS ROLLER TYPE GATES - NOT HOUSED OPERATION O.K. - ONE WINTER.

a perforated sheet metal cover. A number of units of from 3 to 5 kw. each usually are found most convenient.

Designs prepared by the Abitibi Power & Paper Co. for heating the bedded parts and movable parts of Tainter gates are shown in Fig. 3, but have not been used as yet.

The two 18 ft. high by 115 ft. long roller gates at the Bellows Falls Plant of the New England Power Co. in Vermont have been kept in operation throughout last winter (1929) without either housings or heat in the gate proper, but with 4 kw. in heaters in the embedded parts at each end of each gate. The design of these gates is such that as the gates lift they also draw away from any ice which has formed adjacent to the upstream face. The future operation of these gates will be watched with interest as it may be that this feature will make them more suitable for operation in cold climates.

Virginia, Minn., Expands Power Facilities

NEW BOILER PLANT WITH 2 750-HP. STOKER FIRED BOILERS AND A NEW 1500-KW. EXTRACTION TURBINE TO HELP MUNICIPAL PLANT KEEP UP WITH GROWING DEMAND

INCREASING LOAD, both steam and power, and changing industrial conditions made it necessary for the city of Virginia, Minn., to expand their power facilities. The city is in Northern Minnesota on the iron range near what was formerly the heart of the lumber industry. In addition to their coal fired power plant, the city had a 1000-kw. low-pressure turbine installed at the Virginia & Rainey Lakes Lumber Co. sawmill and purchased low pressure exhaust from the lumber company's engines for its operation. Recently the lumber company closed its sawmill and the city of Virginia sold its low pressure turbine and installed an additional high pressure unit in its own plant.

Because of limited space, it was necessary to build a new plant across the street and about 100 ft. from the old boiler plant. This plant, the exterior of which is shown in Fig. 1, houses two 225-lb., 730-hp. Heine boilers fired by six-retort Frederick stokers driven by 5 by 5-in., 325-r.p.m. Sturtevant steam engines. Forced draft is supplied by a Sturtevant type C-10 forced draft fan driven by a 89-hp. noncondensing steam turbine while two 200-g.p.m. Worthington pumps driven by 3600-r.p.m., 50-hp. Moore turbines are used for boiler feed service. Feedwater is heated by 1500-hp. Hoppes Class H feedwater heater with a V-notch recording and indicating attachment.

One of the interesting features of the station is the Chain Belt Co. coal handling equipment, the arrangement of which is well shown in the cross section of the plant, Fig. 2, and by the photograph, Fig. 3. Coal received by railroad is dropped into a track hopper, elevated by a bucket elevator to the roof and distributed to the overhead bunker by a horizontal flight conveyor. This flight conveyor runs the length of the boiler room and discharges by gravity to the 350-t. bunker from which coal is fed by gravity to the stoker hoppers. The elevator is 66 ft. between centers, made up of a Rex combination chain with Rex 12 by 7-in. buckets placed on every fourth link. The flight conveyor is about 70 ft. long, consisting of Rex chain designed for a speed of 52 ft. per min. Ash is removed from the ash hoppers through Beaumont ash pit gates direct to a Koppel industrial car and delivered by Chain Belt Co. skip hoist to the ash bunker visible in Fig. 1 at the back of the power house.

In the present turbine room, they have installed a 1875-kv-a. Westinghouse turbine exhausting to a jet condenser and designed for extraction at from 5 to 15

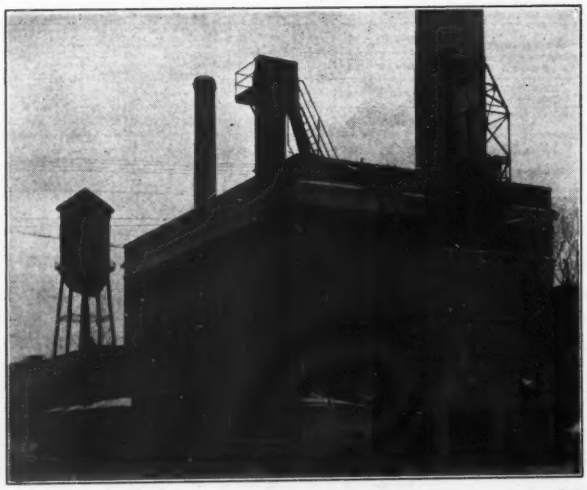


FIG. 1. ETERIOR OF THE NEW BOILER PLANT WITH THE OLD PLANT IN THE BACKGROUND

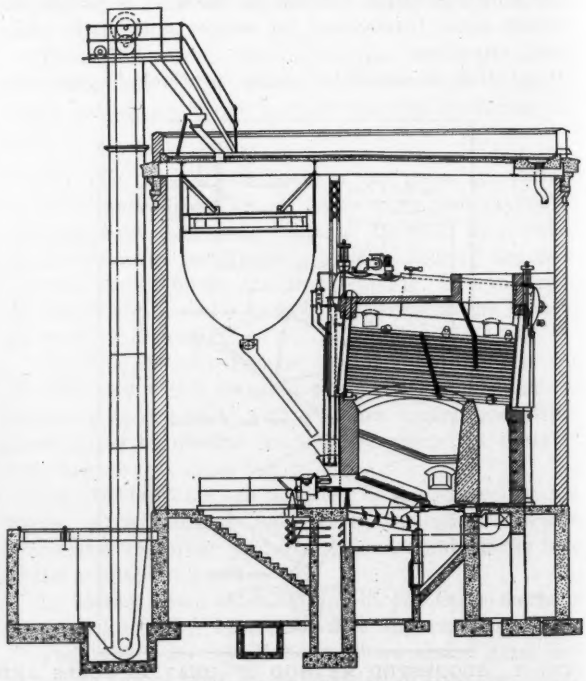


FIG. 2. CROSS SECTION OF BOILER PLANT

FIG. 3. SKIP HOIST, COAL ELEVATOR AND FLIGHT CONVEYOR FROM THE TOP OF THE BUILDING

lb. pressure for the central heating system which takes care of practically the entire city. The condenser is a low level jet type supplied with circulating water by a 17,035-g.p.m. tail pump dual driven by a 40-hp. motor on one end and a 30-hp. turbine on the other. The vacuum pump, with a capacity of 6 c.f.m., is of the

LIST OF EQUIPMENT

2 Combustion Engineering Co. 730-hp., 225-lb. Heine boilers fired by Frederick stokers.
1 Westinghouse Elec. & Mfg. Co. 1875-kv-a. extraction turbine with jet condenser and steam jet vacuum pump.
Stoker drive.....B. F. Sturtevant Co.
Lubricating oil pump.....Marvel Equipment Co.
Stoker meters.....Durant Mfg. Co.
Boiler panels.....Bailey Meter Co.
Recording gages.....Foxboro Co., U. S. Steam Gauge Co.
Thermometers .....Foxboro Co.
Flow meters.....Republic Flow Meters Co.
Water valves.....Chaplin Valve Mfg. Co.
Steam valves .....Lunkenheimer Co.
Steam traps.....Crane Co., Armstrong Machine Works
Ash pit gates.....H. F. Beaumont Co.
Ash cars.....Koppel Industrial Car & Equipment Co.
Sump pump.....Worthington Pump & Machinery Co.
Reducing valves.....McAlier Mfg. Co.
Waste cans.....Justrite Mfg. Co.
Bleeder line check valves.....Atwood & Morrill Co.
2 Worthington Pump & Machinery Corp. 200-g.p.m. boiler feed pumps driven at 3600 r.p.m. by 50-hp. Moore turbines.
2 Worthington Pump & Machinery Corp. 200-g.p.m. service water pumps, 1 driven at 2900 r.p.m. by 7-hp. Sturtevant turbine, the other at 1750 r.p.m. by a General Electric 7½-hp., 220-v. induction motor.
2 B. F. Sturtevant type C-10 forced draft fans, driven by 89-hp. type C-10 noncondensing turbines.
1 Chain Belt Co. skip hoist for ash.
1 Chain Belt Co. coal handling system with a capacity of 250 t. per hr. consisting of a bucket elevator and a drag distributing conveyor.
1 10-t. Whiting Corp. crane.

2-stage steam jet type with inter and after condensers. In addition to this machine, they also have two 1000-kw. Allis-Chalmers turbines set over jet condensers with motor driven tail pumps. The Westinghouse switchboard consists of 13 feeder panels, four generator panels, two exciter panels and one synchronizing panel. A new 10-t. Whiting crane was added to the turbine room at the same time.

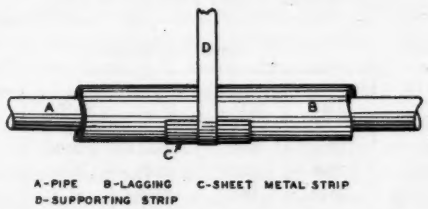
This work is being carried on by M. C. Bright, General Superintendent of the Water and Light Department of the City of Virginia, and by George Schultz, Chief Engineer of the plant.

Refrigerating Pipe Work

By W. E. Warner

COLD STORAGE pipe work whether for carrying brine or gas must be properly proportioned for the amount of material to be carried, it must be properly supported, and all joints well made. With cold pipes carrying brine, the weight of the pipes will often be increased by accumulations of ice and snow on them, this increased weight must be allowed for when fitting the pipe supports. The pipe should be supported so as not to impose any strain upon the joints. In a badly supported pipe line, the joints are always under a strain which will probably lead to the joint leaking.

Pipes which are lagged with insulation are best supported as shown in the sketch. A wide strip of sheet metal is placed halfway round the lower part of the pipe, and the actual pipe hanger is placed round this. This prevents the entry of air into the insulation which would probably occur if the support were passed round the bare pipe and then passed through the insulation.



A-PIPE B-LAGGING C-SHEET METAL STRIP
D-SUPPORTING STRIP

SUGGESTED METHOD OF SUPPORTING INSULATED PIPE

All joints should be well made so as to prevent leakage. This is very important with ammonia gas joints; it is found that ammonia will seep through either red or white lead or, in fact, through any cement except a well made litharge joint. Litharge glycerine cement should always be used fresh and it is advisable to make it up fresh for each joint.

This cement should not be used too liberally or it is possible that it may be forced into the internal bore of the pipe, which will reduce its area. To remove any cement which has been forced into the pipe and also any grit, etc., which may be in it, it is advisable to swab the pipes out with a swab after erection.

This can easily be done if a stout wire is laid in the pipes during erection, and a swab of rags attached to one end of the wire and down through them when installed. This will remove a large amount of grit which would otherwise be carried into the compressor.

Pipes which have to be covered with lagging should always be clean and dry before the lagging is applied, as moisture has a damaging effect on any insulation.

Where pipes pass through a wall, the pipe should be insulated right through; if just insulated up to the edge of the wall and the pipe is allowed to pass through it bare, it is possible that moisture will enter at this spot and spoil the insulation.

ALL TYPES of coal carbonization produce, gas, coke, tar, ammonia and some lighter hydrocarbons. The main products are gas and coke, the calorific value of the former varying from 200 to 1000 B.t.u. per cu. ft., depending on the process.

Capacity of Return Risers for Heating Systems†

INVESTIGATION BY A.S.H.& V.E. INDICATES THAT SIZE OF RETURN RISERS OF STEAM AND VAPOR SYSTEMS DEPENDS MOSTLY ON RATE OF AIR ELIMINATION DURING HEATING-UP PERIOD. BY C. F. HOUGHTEN* AND CARL GUTBERLET**

THIS PAPER marks the completion of the general investigation of the capacity of pipe for carrying steam, condensate, and air in various parts of steam heating systems, as outlined by the Technical Advisory Committee on Pipe Sizes for Heating Systems, and as carried on by the Research Laboratory in coöperation with the Carnegie Institute of Technology. Publication of the results of various phases of the study have appeared in the Transactions[1] of the Society since 1922,

TABLE I. CAPACITY OF 1-IN. RETURN RISER IN SQUARE FEET OF EQUIVALENT RADIATION FOR VARIOUS RATES OF AIR ELIMINATION

Experimental Results Less 20 Per Cent

Pressure Drop Ounces Per 100 Ft	Period of Air Elimination				
	20 Min	30 Min	40 Min	80 Min	From Guide 1930a
¼	1088	1312	1552	2048	
½	1296	1600	1840	2368	
1	1549	1869	2163	2778	1200
2	1792	2208	2509	3226	1704
3	1978	2432	2752	3610	
4	2118	2618	2944	3930	2400

[a] Capacities of return risers for vacuum installations. No rate of air elimination given.

and have formed the basis for the pipe size tables contained in The Guide. This report deals with the capacity of return risers. The investigation was carried on in conjunction with the study of return mains, a report of which was published recently.[2]

The test set-up varied only in minor details from that used in the study of return mains. Steam from a high-pressure line was supplied to an 8-in. dripped main by suitable pressure reducing valves and hand-controlled throttling valves. From the main, the steam was delivered to six unit heaters varying in size from 150 to 2200 equivalent square feet of direct cast-iron radiation. With this arrangement condensation could be supplied at any rate desired through the return main to the head of the riser. To give complete control over the rate of air carried by the return riser, provision was made for admitting air through an orifice flow meter to the supply main.

The base of the riser could be connected to the receiving bucket and the vacuum pump through 5 loops containing 540 ft. of 1-in. dry return main, by closing other connections, the return main could be eliminated. With either connection the system could be operated by gravity or by vacuum pump return.

Conduit of the Tests

One-inch and ¾-in. risers were studied. Provision was made for observing the pressure at two points along the riser. At each of three additional points, a 28-sq. ft. radiator was drained into the riser.

In operating the system, the rate of condensation and air supply to the return riser was adjusted and maintained constant for a sufficient length of time to insure uniform operation and uniform temperature throughout the system. When all conditions were constant, the rate of condensation and the rate of air flow through the riser were determined.

Tests were made at condensation rates of 250, 500, 900, 1200, 1500 and 2000 lb. per hr. on the 1-in. riser and rates of 150, 300, 500, 900 and 1200 lb. per hr. on the ¾-in. risers. For each load studied, the pressure drop along the riser was determined for various rates of carrying air up to the maximum which could be handled without overloading the riser, producing noise or requiring an excessive pressure drop.

*Director, A.S.H.&V.E. Research Laboratory.
**Research Engineer, A.S.H.&V.E. Research Laboratory.
†Abstract of a paper scheduled for presentation at Annual Meeting A.S.H.&V.E., Jan. 27, 1931. Published in Journal of A.S.H.&V.E., Oct., 1930.
[1]A.S.H.&V.E. Transactions and Journal, 1922 to date.
[2]Capacity of Dry Return Mains for Steam and Vapor Heating Systems, by C. F. Houghten and Carl Gutberlet. A.S.H.&V.E. Journal, August, 1930.

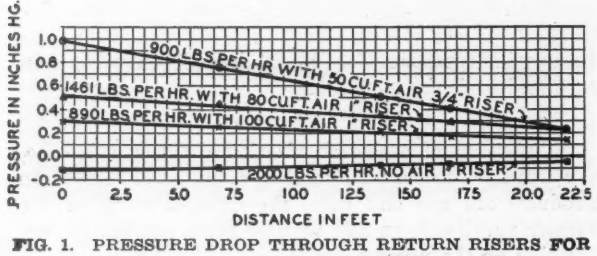


FIG. 1. PRESSURE DROP THROUGH RETURN RISERS FOR VARIOUS AIR AND CONDENSATION LOADS

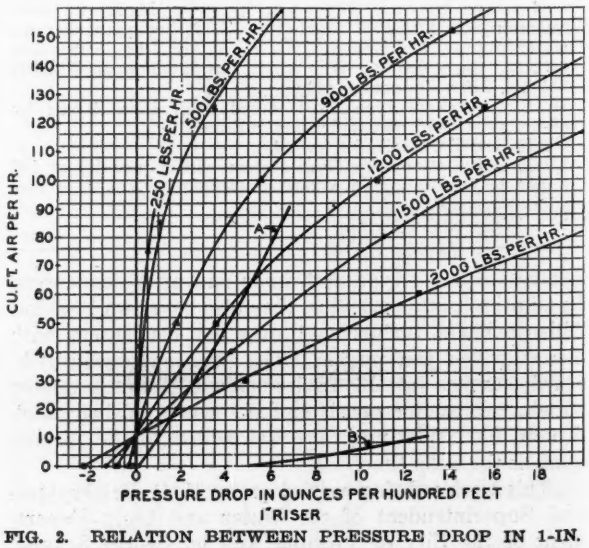


FIG. 2. RELATION BETWEEN PRESSURE DROP IN 1-IN. RETURN RISER AND AIR CARRIED FOR VARIOUS CONDENSATION RATES

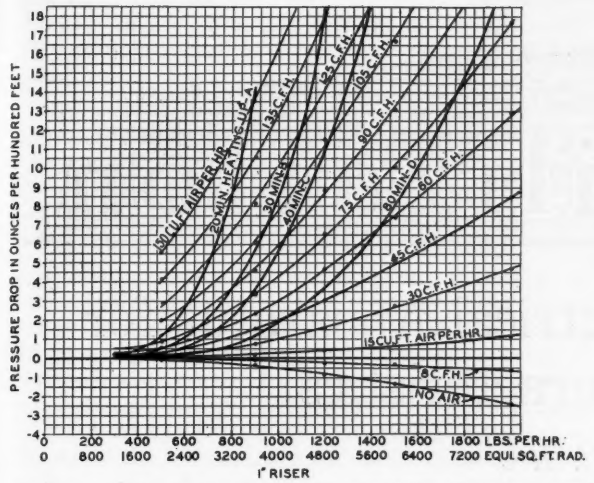


FIG. 3. RELATION BETWEEN PRESSURE DROP AND CONDENSATION LOAD, 1-IN. RETURN RISER

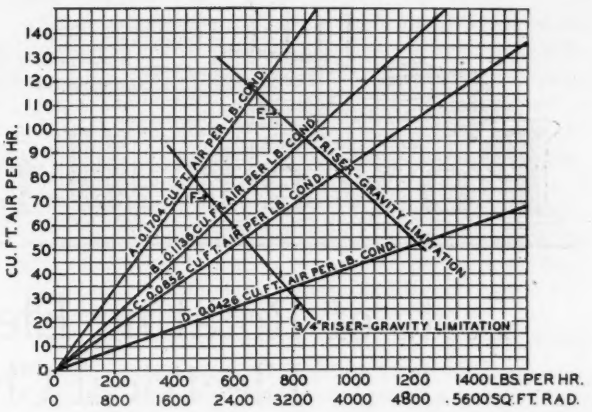


FIG. 4. LIMITATION OF AIR AND CONDENSATION LOADS FOR GRAVITY OPERATION OF RETURN RISERS

Curves showing the relation of pressure drop to load for various rates of air handled, plotted in Fig. 3, give the data necessary for choosing the size of pipe required for any desired pressure drop and for any rate of air condensation handled within the limits studied.

After all radiation in the system is heated up and the air eliminated, the rate at which air will be handled will be extremely low as shown by the tendency of the curves. The capacity for carrying condensation with a given pressure drop under such conditions is extremely high. It is obvious that the size of pipe required for any return riser must be based not upon its capacity to carry condensation when the system is entirely heated up or when little air or non-condensable vapors are being eliminated, but it must rather be based upon the rate of air elimination during the heating-up period, which will depend in a large measure upon the type of radiation and rate of heating up.

In Fig. 4 the limits in rates of handling air and condensation for satisfactory operation are given by curves E and F for the 1-in. and ¾-in. riser respectively. For determination of these limitations, the riser was said to operate satisfactorily when the radiators returning into it become entirely heated in 12 min. without noise.

The relationships given in the curves, Fig. 1 to 4, may be used for developing tables giving capacities of 1 in. and ¾-in. return risers. The acceptance of such tabular values must, however, be based upon certain assumptions, including the allowable pressure drop, the rate of heating up or air elimination and any factor of safety desired for covering other contingent factors. These assumptions cannot be determined by laboratory test but must be based upon experience gained through practice and judgment.

TABLE II. CAPACITY OF ¾-IN. RISER IN SQUARE FEET

Experimental Results Less 20 Per Cent

Pressure Drop Ounces Per 100 Ft	Period of Air Elimination				
	20 Min	30 Min	40 Min	80 Min	From Guide 1930
½	480	544	576	688	
1	611	656	714	909	700
2	771	845	922	1197	994
3	886	982	1088	1421	
4	966	1094	1120	1693	1400

Table I gives the capacity less 20 per cent of a 1-in. return riser in equivalent square feet of radiation for various pressure drops and various rates of heating up a system in which all steam is condensed in tubular cast-iron radiators having a volumetric capacity of 0.0142 cu. ft. per square foot of radiation.

This 20 per cent reduction in capacity may be considered a factor of safety for variation in internal diameter and internal smoothness of pipe, constrictions due to improper cutting, reaming, and the use of dope, and other contingent factors. The acceptance of a factor of 20 per cent is in conformity with the earlier practice of the committee which developed the pipe size tables for the supply side of steam heating systems contained in The Guide, 1930, and is not the result of this laboratory investigation. Table III gives the maximum rate of air elimination.

It is not the purpose of this investigation to establish the desirable heating-up period on which to base pipe size capacities; however, it may be of interest to point out that a 20-min. heating-up period is probably much shorter than desirable for most buildings for the reason that in most instances it is not necessary or desirable to heat up all radiation from the cold condition in this period of time.

TABLE III. MAXIMUM RATE OF AIR ELIMINATION FOR 1-IN. AND ¾-IN. GRAVITY RETURN RISERS

Experimental Results Less 20 Per Cent

Capacity Sq Ft Equivalent Radiation	Maximum Rate of Air Elimination			
	1 Inch Riser		¾ Inch Riser	
	Time, Min(a)	Cu Ft Air/Hr	Time, Min(a)	Cu Ft Air/Hr
1280			15	89.5
1600			23	74.5
1920	16	124	34	60.0
2240	20	112.5	50	45.5
2560	27	100.5	88	31.0
2880	34	89.5		
3200	43	78.5		
3520	56	67.0		
3840	74	55.5		

[a] Time necessary for eliminating air from a system in which all steam is condensed in tubular cast iron radiation having a volumetric capacity of 0.0142 cu ft per equivalent square foot of radiation.

Tests of Rotating Electrical Apparatus for Electrical Characteristics

By A. C. Roe

WHEN A MOTOR or generator is in operation, a portion of the power input or output is expended in supplying the losses of the machine. The major losses such as, core, copper and that due to power factor, which vary with age of the machine, load, and line voltage, must be kept to a minimum to obtain the highest operating efficiency.

In the measurement of power, a careful study of existing conditions should be made to permit selecting the most suitable place to connect the meters. Also, thought must be given to the losses in the meters, instrument transformers, and in the leads and connections. In general, meter and instrument losses can be ignored when testing machines larger than 5 hp. but, where the current rating is large, the lead and connection losses must be considered.

Space forbids description of meters and connections, restricting the discussion to pertinent facts on the subject of standard or commercial loss tests.

Complete determination of the performance of any rotating electrical apparatus is possible only when its characteristics, mechanical, electrical, economic, heating and insulating effectiveness have been established. Under electrical operation we have, copper losses, or the power necessary to force a current through any winding, —equal to the resistance of the winding or circuit expressed in ohms times the square of the load current flowing; this necessitates ascertaining the resistance of all circuits in any winding under test.

For measuring resistance, either of two methods can be employed; the drop of potential, using a voltmeter and ammeter, or the comparative method using a suitable bridge. The Wheatstone bridge can be used with fairly close results for resistances from 5 to 10,000 ohms, the Kelvin or double bridge being used for lower resistances, as it is independent of the current circulated and requires no correction of the reading for the resistance of the leads.

When using the voltmeter-ammeter method, the current circulating must be kept to a value that will permit obtaining readings well up on the meter scale, yet will not heat up the circuit under test. From ¼ to not more than ½ normal operating current should be used.

Resistance measurements should be made for the armature winding, series, shunt, commutating, and compensating field circuits, taking each circuit separately. On induction motors, measure the resistance of the primary winding only, for the squirrel-cage type and of the rotor resistance when it is of the wound-rotor type.

Cold resistance of any armature should be measured with the brushes on the commutator, readings being taken between adjacent plus and minus brush arms. The resistance of the series commutating and compensating coils is quite small, requiring for accuracy the use of a bridge and taking the average of several readings for each circuit.

Included in the shunt field copper losses are the losses of the rheostat: when separate excitation is used, the copper loss of the field, only, is used. Brush drop can be assumed as two volts times the total armature current. In the case of synchronous converters, ¼ volt per ring times the a.c. current per phase is added to the brush losses.

When a complete performance of any machine is desired, current readings and summation for each fractional load as ¼, ½, ¾, full and 25 per cent overload, should be made, or readings and summation taken for any point of loading that it is desired to check.

Core, friction, and windage losses of any machine may be checked by either of two methods: (1) With the machine driven by a small shunt wound d.c. motor; (2) Operating the machine under test as a motor. When it is desired to separate the core losses, method 1 must be used. The second method is not as accurate as the first but is used mostly for small machines, where running-idle losses can be assumed consistent at all loads and one reading taken to include the total is sufficient.

When using the separate drive method, the machine should be separately excited. The shunt motor used should be of the commutating pole type and have a capacity not less than ¼ or more than ½ of the friction losses to be measured.

Take readings of the armature volts and amperes, field amperes of the driving motor, also of the armature volts, field amperes and speed of the machine under test. Include the collector ring voltage on synchronous converters.

After running the machine until the bearing and brush friction becomes constant, obtain an average reading of the driving motor armature amperes, by taking a

number of readings when the speed is constant and zero field on the generator, also read all meters and speed. This average is used as a base for computing the core losses.

Next, excite the field of the machine being tested to approximately 1/5 normal voltage; increase the armature voltage in suitable steps, taking complete readings at each step. Also check the friction at the middle and end of run.

For checking brush friction losses, run in the brushes and have the commutator well polished. Then, with all brushes on the commutator, take a reading of the driving motor input, also a reading with all brushes up. On an average the brush friction can be assumed as being 10 watts per square inch of brush area per 100 ft. per sec. circumference velocity. The total brush friction losses in watts equals the watts with all brushes down, minus the watts with all but one brush per arm raised, divided by the number of brushes raised, multiplied by the total number of brushes.

To test friction and windage; with all brushes up, take a full set of readings on the driving motor; then shut it down, remove the belt and take no load readings of the driving motor, using the same voltage and field current as was used for the first no-field reading with brushes up.

Saturation test data can be obtained during the core loss test. At no load with brushes on neutral, take shunt field current readings at the same time that other readings are obtained, increasing the field current carefully to prevent exceeding the required voltage. Take sufficient readings to carry the saturation curve above or up to approximately 35 per cent above normal voltage. Tests described above will permit constructing the various performance and characteristic curves or charts for the simpler d.c. machines but, to check the complete performance of an induction motor, the following items must be ascertained. Power factor, speed and efficiency at all loads at normal frequency and voltage; the ratio of maximum pull out to full load torque; the ratio of starting torque to running torque. These characteristics are commonly determined by the circle diagram or analytical method.

Readings necessary for the circle diagram method are, primary and wound-rotor resistance, full load slip (analytical), locked rotor current and power at normal voltage, also idle-running current and power at normal voltage.

When taking resistance hot and cold readings, use a bridge. Taking readings between terminals on the stator and on the rings of wound rotors; check room and winding temperatures. The above tests can be made on an induction motor and the values obtained, tabulated and used for comparison with similar tests made at regular intervals, to check the motor performance. A careful study of the tests will indicate the condition of the motor, as a large discrepancy in the resistance of one or more phases, indicates short circuits or coils cut out. Other variations as compared to known values of similar machines will give indications of the machine's condition or characteristics.

Motor Speed Control by Varying Frequency*

WIDE VARIATION POSSIBLE AT CONSTANT LOAD AND HIGH EFFICIENCY. SUGAR CANE MILL DRIVE AS AN ILLUSTRATION. BY C. A. KELSEY**

FOR VARIATION of speed through a wide range when a large constant load is to be driven, use of a separate generator whose conditions are varied to control motor speed has been found effective. When direct-current is used, the Ward-Leonard system of varying generator voltage by varying field excitation, generator speed being constant, has been used.

Both generator and motor fields are excited from an outside, constant-voltage source and, by using large motor field coils, relative speeds of motors on the system can be adjusted over a considerable range by changing field excitation of individual motors through adjustment of rheostats in their field circuits.

Speed change for the system can be carried through almost any range desired.

For alternating-current, like results can be attained by varying the speed, hence the frequency and voltage of the generator. Relative speeds of motors on the system can be varied by varying rheostatic resistance in the rotor circuits over a 10 per cent range.

SUGAR CANE MILL DRIVE

One application of these systems is found in mills for crushing sugar cane. Present practice train or tandem of grinding rolls consists of one or two crushers for breaking and splitting the cane and three to six three-roller mills which further crush and express the juice. In passing through the various rolls, the cane mat decreases in thickness, depending upon the percentage of fiber, the extraction of juice, the practice of maceration or saturation and the condition of the roll surfaces. Any material change in these factors requires either a readjustment of roll openings or of relative speeds in order that the extraction ratio shall be maintained at a high value.

Where the character of the cane changes little from day to day, relative speed changes are infrequent. The other causes for speed changes are casual and the speed adjustments serve as a guide for changing the roll openings. The control scheme can, under these conditions, be made simple by making the adjustments at the individual motor panels instead of at the master control station. If, however, close supervision is exercised to obtain maximum extraction at all times, all control should be centralized and afford a greater range of speed adjustment.

Variation of the grinding rate is necessary during the crop, due to fluctuations in the cane supply or the capacity of the factory. It is usually more economical to grind continuously at a variable rate than to grind at a constant rate with short shutdown periods. When

*From a paper before the Hawaiian Sugar Technologists.
**Industrial Engineering Dept., General Electric Co.

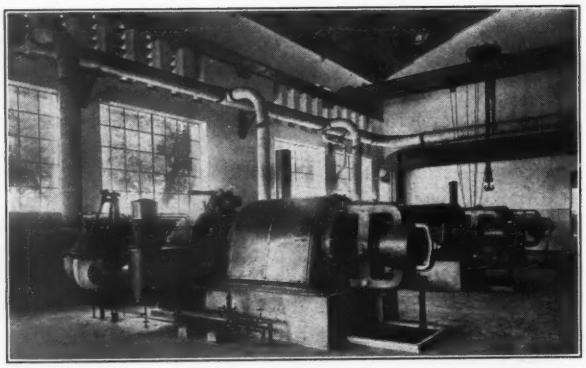


FIG. 1. THREE GENERATING UNITS WITH EXCITERS FOR SUGAR MILL VARIABLE SPEED DRIVE

the grinding is changed from normal, it should be accomplished in a simple manner without disturbing the relative roll speeds. Moreover, the power efficiency and steam balance should not be materially altered.

With rheostatic control alone, it was found to be impractical to operate a cane mill in a stable manner at less than 10 to 15 per cent below normal speed. Even though this were possible, the power and steam balance would be upset. When the mill speed is reduced 20 per cent, the power input and the exhaust steam remain at 100 per cent but the bagasse or fuel and the evaporating steam drop to 80 per cent of normal. If the normal steam and power requirements are closely balanced, there may then be an excess of exhaust steam and a deficiency of fuel.

Variable Frequency System

For the variable frequency system is employed a variable speed turbine generator unit which supplies the power solely for the roll motors. Wound-rotor motors, individually driving the crushers and mills, are provided with rheostatic control for adjusting the relative speeds 10 per cent downward from normal to compensate for roll wear and changes in the fiber mat.

Speed of an induction motor exerting constant torque is proportional to the speed or frequency of the alternator. If the voltage is maintained in proportion to the frequency, the current input will remain constant. A speed range of 110 per cent to 75 per cent of normal is provided by the turbine speed governor which gives a like range in the grinding rate.

Three generators are usually provided, one to furnish power for the roll motors at variable frequency; one at constant frequency and voltage for other power supply; a third to serve as a spare for either of the others. Figure 1 shows three 1000-kw. generators with direct-connected exciters for a sugar mill at Redjo Agoeng, Java. The spare unit may be arranged with a double-throw switch for connection to either roll-motor or general power systems, or all three units may have double-throw switches for connection to either of two sets of bus bars. The latter arrangement is more flexible but involves somewhat greater complication and cost.

Simplification of the power equipment and switching is attained by supplying direct-connected exciters and an individual voltage regulator with each generator. Each generator panel is then self-contained with all switches, meters, relays and the voltage regulator mounted on a single panel. This arrangement avoids the parallel operation of generators and exciters and use of exciter buses. Synchronizing equipment is, however, provided solely for paralleling the generators to shift the load from one machine to another without shutting down the mill.

Control Equipment

Excitation of an alternator carrying constant load current with voltage proportional to frequency is constant. The exciter, therefore, must deliver a constant current over a speed range of 110 per cent to 75 per cent of normal. This requirement can easily be met by selecting an exciter to give the rated output of current and voltage at the lowest speed and a drooping saturation with decreased excitation at high speed. The voltage regulator is likewise of special design, having its potential circuit highly reactive instead of mainly resistance. The current in a reactive circuit is constant, if the voltage is maintained proportional to the frequency. This principle is utilized to regulate the voltage of the generator.

Overload protection for the roll-motor feeder cables is necessary when the generator is connected to that feeder but is not required when feeding the constant-frequency general power bus. Selective action is attained by connecting current transformers for the oil circuit breaker trip coils in the roll circuit side of the double-throw disconnecting switches. The voltage regulator, being connected at all times to its generator and exciter, is automatically switched to the proper circuit. Switches are provided on the generator panels so that the switchboard attendant can regulate the frequency of a given generator or he can place the turbine speed under control of the mill operator.

Power plant equipment is simple, though of special design and is easily operated without the possibility of wrong connections because the automatic switching features are inherent in the design and are along conventional lines.

Control equipment for the roll motors consists of a main control panel, a drum switch connected to a speed regulating resistor for each motor and a master control panel for all motors.

Main panels are equipped with forward and reverse main line contactors, secondary accelerating contactors, an oil circuit breaker, overload and undervoltage relays

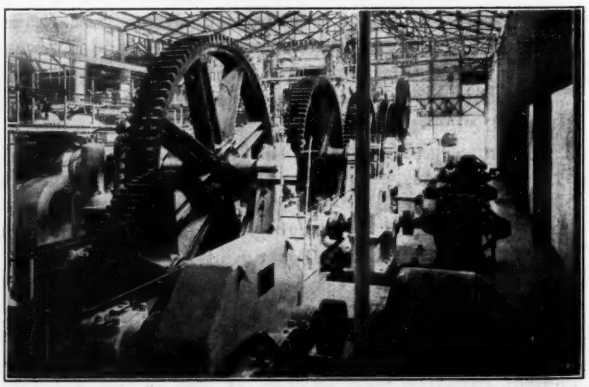


FIG. 2. FIVE SLIP RING MOTORS DRIVING CANE ROLLS AT 45 TO 66 CYCLES AND 330 TO 484 V.

and a control circuit switch. Drum switches and the accelerating and speed regulating rheostats are usually located with the main control panels adjacent to the motors to shorten the heavy motor secondary cables.

No special design is incorporated in the design of the motors or the control equipment. The nominal voltage of 440 v. allows the use of open induction motors.

Advantages of Frequency Control

Good engineering is the selection of apparatus that produces the required results at the lowest first cost and cost of operation. It is unwise to incorporate expensive features which cannot be fully utilized and which may be a source of operating expense. For these reasons, it has been the practice to employ as simple designs or types of apparatus as will do the work.

Change in mill speed is accomplished with the a.c. system by the operation of a switch, which adjusts the

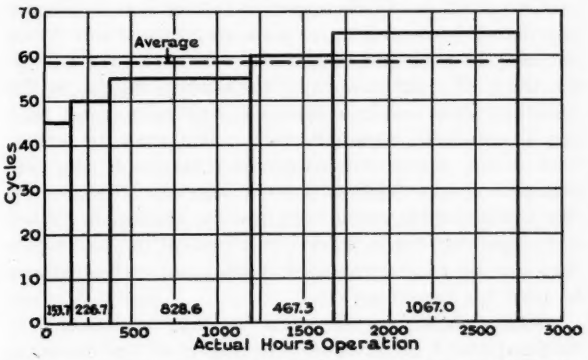


FIG. 3. OPERATING CHART OF VARIABLE FREQUENCY DRIVE

turbine speed governor, located at the master panel or at the power plant.

Frequency of adjustment throughout the crop in a two-tandem factory is shown on the chart to have been 62 changes in a crop period of 122 days or on an average of one every other day. The tandem was operated at approximately 10 per cent below the normal for about 70 per cent of the total time. On days when complete shutdown periods were anticipated, the rolls were operated at maximum speed to shorten the running time.

Relative speed adjustment of the mill speeds by a.c. rheostatic control is limited to 10 per cent but, for the crushers, 15 per cent range can be used. Reliability of the a.c. system is greater because of the absence of commutators and the simplicity of the power equipment.

Power efficiency plays a small part in a sugar mill but economy is important. This means that the bearing friction losses and the electrical losses represent only a small amount of fuel but, where the power and steam balance can be maintained, the system is economical from the power standpoint.

Efficiency of an induction motor is high at normal speed, likewise, the efficiency of the a.c. power plant machines. The a.c. motor, operating at 45 cycles is but 2 per cent less efficient than at 60 cycles while the power factor is unchanged.

Efficiency of an a.c. motor at reduced speeds by rheostatic control is in proportion to the speed but, in general, the a.c. motor with its control is comparatively low in cost.

Report on a large Cuban mill with the a.c. variable-frequency system shows a maintenance expense for cleaning and repairing the seven motors and control equipment at the end of the run of $368, of which $45 was for material and $323 represented labor.

Choice of the electric system rests mainly on the operating characteristics required. If a greater relative speed adjustment than is afforded by the a.c. system is necessary or of value, then the d.c. system must be used. But it would be unwise to install a lot of expensive machinery to provide a wide speed range, if new methods of operation will permit use of the less expensive equipment.

Good Ground Connections

Bill Hayward was an old-time lineman employed by one of the eastern railroads a number of years ago. One morning the wire chief instructed him to proceed to a small town about 100 mi. away to cut in a set of telegraph instruments and he was told that a new helper, just hired that morning, would be on hand to assist him with the work.

Shortly before noon Bill reached his destination and found the young man on hand to help him. Bill put him to work boring holes for the porcelain tubes, uncoiling wire and running in the ground wire, while Bill climbed the nearest pole and strung in the service drop, Bill made the necessary connections, hurrying in order to catch the afternoon train back to headquarters to avoid laying over in the little town for the night.

Casual inspection led Bill to believe that everything was O.K. He tried to get the wire chief for an O.K. but found the instrument absolutely dead. He could hear the train whistling in the distance as he hurriedly checked over the layout. Finally, as the train came to a stop outside, he ran his eye over the ground wire which had been neatly tacked down on the leg of the table, along the mop board and to a dark corner where it entered a small, clean, wooden box filled with fresh loam that had been dug up by the helper and carried in while Bill was on the pole.

Needless to say, this was *not* a good ground. Bill, to his sorrow, was obliged to run in a new ground wire, and drive a ground rod, while the train that he had expected to take was many miles away.

All ground wires should be carefully fastened to the devices they serve and well grounded to a water pipe or ground rod. They should be of sufficient size to carry any abnormal current that may flow over them. They should be well supported between the apparatus and the ground. Nothing can look worse than a sloppy ground wire, aside from the danger that such an installation creates. Any machine that is to be grounded, should be thoroughly and permanently grounded. Bill learned a lesson from the above experience that he never forgot.

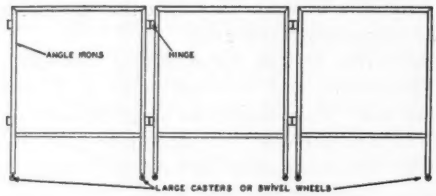
Cold Spring, Minn. Chas. A. Peterson.

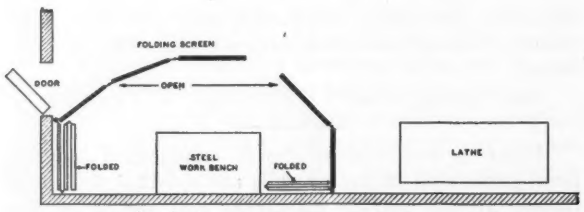
Loose or unbuttoned sleeves, unbuttoned jumpers, loose gloves and flappy overalls are constant sources of danger around moving machinery and should be prohibited.

Folding Screens to Shield Welding Work

NOT LONG AGO a friend of mine told me of a rather ingenious scheme which he saw during a trip through the middle west. He had a considerable amount of work to be done around a large chemical industry plant and, although most of the work was out around the plant where he utilized a portable welding outfit, there was always some work which could be done best in the shop and then there was always a number of small jobs which could be saved up to fill in time when the men were not busy on something else. He did not have machine shop space available to give over to this work permanently and so the folding screen arrangement which I am about to describe appealed to him. The arrangement sketched is about as he showed it to me, a small space in one corner of his machine shop, he and needless to say I claim no originality for this but I have never seen a similar arrangement and I have worked in many plants.

It is important when welding that the torch or arc be shielded so as to protect other workmen from the bright light and ultra violet rays which emanate. Where a permanent welding shop can be set up this is comparatively easy but where the space must be used for something else, when the welders are not busy there, it is not so easy to make things convenient for both. This scheme is to use folding screens which are hinged and fold back against the wall when not in use. They can be pulled out on a moment's notice and folded back as easily.





FOLDING SCREEN MAKES CONVENIENT WORKSHOP PARTITION

Construction of this screen is too obvious to require any detailed explanation as such an arrangement would probably be made out of material which was available at the time. The framework of the screens can be welded from any light material available, light angle iron making a satisfactory construction. The most important part is the wheels or casters and hinges as the convenience of the folding screens depends largely upon the facility with which they can be arranged. When not in use they can be folded back against the wall where they are out of the way so that the space and bench can be used for something else.

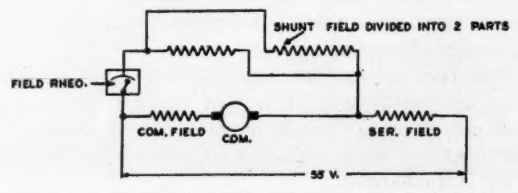
Many states require that welding operations be shielded and I understand that inspectors are becoming increasingly insistent on some means of protection as welding is becoming more and more common throughout industrial plants.

Brooklyn, N. Y. P. F. ROGERS.

Changing a Motor Into a Half Voltage Generator

SOMETIME AGO, an old customer bought some machinery to drive a generator for battery charging service and sent the generator to our shop for assembly on a common baseplate. He explained that he had bought it from a used-machinery house at quite a bargain. When the generator (?) arrived, the writer was much surprised to find that it was a 125-v. compound-wound motor, which was in fine condition.

Realizing that it might be a difficult thing to exchange the machine for another, I determined to use it if at all possible. A little study revealed the fact that almost any shunt or compound motor can be made to generate nameplate voltage if it is run at 35 to 40 per



DIVIDING THE SHUNT FIELD OF A MOTOR INTO TWO PARALLEL PARTS REDUCES THE VOLTAGE WITHOUT IMPAIRING THE AMPERAGE

cent greater speed than its motor speed, providing the field is not too highly saturated. But it was later discovered that the customer wanted 55-v. current instead of 125-v. for his charging arrangement.

Recalling that voltage generated is almost directly proportional to speed, in the new situation the speed was adjusted to be 55 ÷ 125 of the generator speed above found. Then in order to keep the total field flux the same, the shunt field was divided into two parallel paths as shown in the sketch herewith. With these changes made, the test in place showed that the machine generated 55 v. with nameplate amperes. In this case, this accommodation to a customer saved going back to him with a lot of correspondence about things he understood little and led the way to a profitable order later.

If it had been desired to generate current at 250 v. the generator speed for 125 v. would have had to be doubled and double kilowatt rating could have been gotten from the same generator, provided the insulation was sufficient. In this way considerable juggling can be done with a given direct current generator as to voltages and speeds. If the speed is to be increased so that the armature surface runs at more than 6000 ft. per min. the matter should be taken up with the builders to see whether such proposed speed is safe. When changing shunt motors over to generators it may be that the machine may not be stable and in such a case it would be necessary to wind a few turns of suitable wire to carry full line current around the field poles, thus producing compounding effect enough to hold the voltage at full load.

York, Pa. JOHN S. CARPENTER.

Capacity of Water Piping Systems

YOUR ARTICLE Capacity of Water Piping Systems which appeared on pages 14 and 15 in the issue of January 1, 1931, should be of considerable interest to industrial plant engineers. Even if the information given in the above-named article constituted the only data that such a plant engineer used for the design of his piping systems, he could not but benefit from its use.

Probably the most reliable set of tables for general use and certainly the most widely used, covering the flow of water in pipes, aqueducts, sewers, and so on, were prepared by Williams and Hazen under the title Hydraulic Tables, published in 1905. This book not only gives the loss of head for all standard sizes of pipe from ⅛ to 144 in. in diameter and for a wide range of coefficients, but also carries an exceptionally clear introduction and lists of tests on which the tables for the loss of head are based. A slide rule has also been developed, based on these tables, which makes their application exceptionally easy and accurate.

Contrary to your statement, there has been a very large amount of experimental data collected, tabulated and analyzed and, while it might appear to the layman that inconsistencies existed in such data, they exist not because of imperfect theoretical knowledge but because of their interpretation.

Many other reliable formulas, aside from those of Saph and Schoder to which you refer, have been based upon careful experiments. Studies of these individual formulas reveal that many of them have been made under conditions applying to a particular pipe line or kind of pipe and accordingly cannot be compared. This does not mean, however, that the formulas or tests are inconsistent.

*All formulas for the flow of water in pipe are based on the original Chezy formula $V = C\sqrt{R\,S}$ developed in 1775, in which:

V = Velocity in feet per sec.
C = Coefficient of friction due to interior roughness of pipe
R = Hydraulic radius = a ÷ W_p
a = area
W_p = Wetted perimeter
S = Slope in feet per thousand (Hydraulic gradient)

In this formula it was soon found that the flow in a pipe did not vary directly as the square root of either R or S. Accordingly, these two elements were removed from the radical and various exponents assigned. As suggested by Hazen, "In recent years the range of exponents for R and S has been well taken up and any exponents that may be selected will be found to have been already used by someone."

For ordinary application other than laboratory work, the percentage variation in flow between the various formulas is not unduly serious. Any one of the recognized formulas by Chezy, Lampe, Fenkell, Moritz, Scobey, Saph, Schoder, Weston, Williams and Hazen, etc., might be used. It would merely mean that we were using a different "yard stick" and is an indication of the difficulties encountered in attempting to assign definite fixed mathematical terms to a problem in which it is practically impossible to measure or record *all* of the variations. It would, however, simplify the study of this subject if one formula, best suited to apply to pipes in general, could be used, in which the coefficient C might be varied to suit existing conditions. As stated by Hazen, "there is a distinct advantage in using only one formula, for one becomes thoroughly accustomed to it, accumulates his data in its terms, can much better judge all of the varying conditions and is less likely to make errors in its application."

In attempting to compute the capacity of a pipe line or to figure probable loss of head after the pipe has reached a certain age, it is essential to know everything possible about the water to be handled. In most cases, contrary to the statement, credited to the Cast Iron Research Association, the quality of the water is such that the carrying capacity of the pipe line *is* greatly affected, not directly by the age of the pipe but by the tuberculation which more often than not develops within the pipe. This tuberculation may be proportional to the age of the pipe but is not usually directly proportional. Again, contrary to the statement that "waters that cause tuberculation are rare exceptions," it is a *rare* water that does *not* cause tuberculation. Accordingly, in designing pipe lines, your diagram Fig. 2 (C = 100 in Williams and Hazen tables) should be used, indicating future conditions, rather than your diagram Fig. 1 (C = 120 — 130 in the Williams and Hazen formula) which indicates the flow in a new, clean, smooth main.

Application of your diagrams applies particularly to

*Relation of Interior Condition of Water Mains to the Coefficient of Roughness, A. T. Clark, American Water Works Assn., Volume 22, No. 4, April, 1930.

small piping within a plant. If supply mains are to be constructed through which a general water supply is to be furnished to the entire plant for commercial, domestic or fire uses, the services of an engineer experienced in water supply work should by all means be obtained to determine upon the supply available, the proper and economical size of main to meet present and future requirements, the kind of pipe and the lining or protection which should be used to prevent or defer as far as possible serious tuberculation. Careful chemical analysis of the proposed supply to definitely determine the quality of the water and its fitness for the particular plant requirements should also be determined.

New York City. A. T. CLARK.

Automobile Axles Make Excellent Anchor Posts

SEVERAL TIE or anchor posts were needed around a construction job. The ground was so hard that nothing of wood strong enough could be driven into the ground.

POINTED ENDS OF AUTOMOBILE AXLES PERMIT THEM TO BE DRIVEN EASILY INTO THE GROUND AND GEARS SERVE TO PRVENT SLIPPAGE IN ANCHOR POST SERVICE

From the scrap pile of a nearby garage a number of old rear axles were procured. The ends of the shafts were beaded over to hold on securely the small differential gears. As the wheel ends of the axles were already decidedly tapered and pointed, it was an easy matter to drive them quickly but solidly in the ground. The chain was wrapped safely under the gears and the pulley hooked. This little makeshift, in a pinch, made an anchor safe and strong.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Steam Station Performance

ON PAGE 178 of the February 1, 1931 issue, Paul H. Jeynes discusses steam station performance, formulas and methods of predicting fuel consumption of power stations.

While the purport of this study is understood, at the same time it seems unexplained why authorities on this subject generally consider the efficiency of different operators to be a fixed quantity. No doubt in many plants, especially those having a small number of units, the standard may be fairly consistent, but in the large stations built several years ago and carrying peak loads or in industrial plants can this be said to be true? Furthermore, how many plants of any type check the overall economy of each shift?

It is general practice in many plants to change watches every two weeks but comparative performance of the different crews under similar load conditions and injection water temperature is not always made. We have determined, by keeping coal rate curves and records of eight hour periods, that in the operation of an industrial plant this difference in operators was quite surprising.

While there may be more opportunity for waste that cannot be easily checked up in an industrial plant, at the same time I remember several years ago while operating a large central station, the different ways in which the chief engineers handled their shifts. For example, on week days one operator would insist on having four or five units ready at 3:00 o'clock in the morning preparatory for the 6:00 o'clock increase in load. This plant had a number of vertical turbines and it meant five circulators and step bearing pumps operating from one to three hours unnecessarily.

Another operator gauged his time a little closer and saved this expense. In another instance, some switchboard operators would blow for a turbine to be up to speed sooner on an expectant load than others would. Many times turbines were held on the line for five or six hours with vacuum trouble when it would have been possible to put the load on another machine in better shape.

Of course most plants have a system of checking firing operations for individual shifts and there are many recording instruments in places where losses can plow deep; but are these recorders always checked with an eye to each detail bearing on economy? Where considerable equipment is installed, it would take a large profitless force to analyze all procedures of operators and such a force would not be necessary for records can be noted each shift instead of daily and very valuable comparisons can be made.

Waterloo, Iowa. JOHN U. MORRIS.

Largest Unit-Fired Boiler

IN THE ARTICLE, "Champion Coated Paper Company Builds an Outstanding Power Plant" which appeared on page 1328 of the December 1, 1930 issue, the statement is made that the boiler installed is "the largest unit-fired pulverized coal boiler ..... yet built." In the Plant Atkinson of the Georgia Power Co. are installed two 30,200-sq. ft. boilers, each of which is unit-fired. Each boiler is guaranteed to deliver 450,000 lb. steam per hr. at 475 lb. gage, 740 deg. F. Further information regarding Plant Atkinson appeared on page 448 of the April 15, 1930 issue and on page 1165 of the October 15, 1930 issue.

JOHN M. GALLALEE.
Professor of Mechanical Engineering,
University of Alabama, University, Ala.

DRY AIR consists of over 90 per cent by volume of oxygen and nitrogen but in nature it contains small amounts of argon, carbon dioxide, water vapor, helium, krypton, neon, xenon, ammonia, nitrous acid, nitric acid, supfurous and sulfuric acid. For combustion purposes, only the oxygen and nitrogen are considered.

Questions and Answers

Piping Color Scheme

WE WOULD APPRECIATE any information you can give concerning a color code for piping. We understand that there is a standard color code for piping in industrial plants. E. C. G.

A. Three years ago the American Standards Association approved a scheme for the indentification of piping systems. This scheme is intended for identification of piping systems in industrial plants, not including pipes buried in the ground and electric conduits. Fittings, valves and pipe coverings are included but not supports, brackets or other accessories.

All piping systems are classified by color according to the nature of the material carried. Each piping system is placed, by the nature of its contents, in the following classification:

F — Fire protection equipment—Red
D — Dangerous materials—Yellow (or orange)
S — Safe materials—Green (or the achromatic colors, white, black, gray or aluminum)
P — Protective materials—Bright blue
V — Extra valuable materials—Deep purple

At conspicuous places throughout a piping system, color bands are painted on the pipes to designate to which one of the five main classes it belongs. If desired, the entire length of the piping system may be painted in the main classification color. Further, the actual contents of a piping system may be indicated by, preferably, a stenciled legend of standard size giving the name of the contents in full or abbreviated form. These legends are placed at the color bands. The identification scheme may be extended by the use of colored stripes placed at the edges of the colored bands.

Bands, legends and stripes are placed at intervals throughout the piping system, preferably adjacent to valves and fittings, to insure ready recognition during operation, repairs and at times of emergency. A recommended classification, under this color scheme of materials carried in pipes, includes as dangerous, combustible gases and oils, hot water and steam above atmospheric pressure; as safe, compressed air, cold water and steam under vacuum.

Hot-Water Circulation in Service Lines

REFERRING TO my sketch, which is a line diagram of the service-water pipe system of our building, on the line AB, where there are only two wash bowls, the water will not stay hot while on all other lines the water always is amply hot. Why is it that the water in the line AB is not as hot as that in the other lines? A. D.

A. The water probably circulates more readily through that part of your plant which is closest to the boiler because of less resistance to circulation. The line AB, you will note, is much farther from the boiler than the other lines and has more turns in the piping. Less water is used here also, since there are only two wash-bowls.

Your trouble could be overcome, we believe, if you would partially close the valves leading to all of the lines except the AB line. In this way, you will decrease slightly the flow in those lines, therefore the amount of

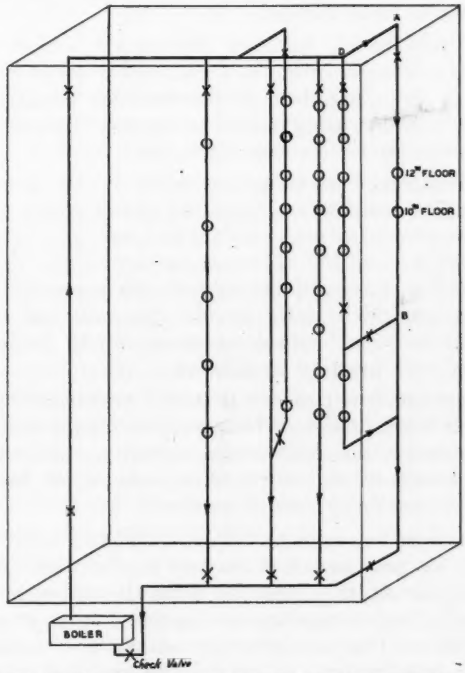


DIAGRAM OF HOT-WATER PIPE LINES IN BUILDING.
X = GATE VALVES; O = WASH BOWLS

water going through them will be reduced proportionately, leaving the line AB freer to take its full supply of water. The idea is to adjust the valve openings so as to give about the same flow of water in each circuit. The adjustment will be practically correct when the temperature of all circuits is the same at a time when no water is being drawn off.

Leakage Test in Steam Line

WITHOUT BREAKING a joint on the line or using a sound test, how do you test for leakage of a check valve on the return line of a low-pressure boiler when the stop valve on the steam line leaks? J. A. F.

A. Leakage of a check valve on a return line of a low-pressure boiler will be evidenced by the rise over normal temperature that will occur in that part of the piping when the stop valve is closed or radiator air valves are opened so as to reduce the pressure in the system considerably below that in the boiler.

Editorial Comment

Ice Industry Research

Need for research in the ice industry was voiced recently by George Lang, one of the men who as chief engineers of the American Ice Co., has been extremely influencial in lifting the ice plant from the haphazard state it was in a decade ago and placing it solidly on its present pedestal worthy of a place with any engineering company.

There is a limit to which practical designers and operating engineers can be expected to go in research investigations. At the same time these investigations must be carried on by somebody if stagnation of the industry is to be avoided.

So far the ice industry has lagged behind other branches of engineering, in fundamental investigations. In fact, even practical or experimental research has lagged woefully, being limited to a few of the more alert universities and a few manufacturers.

Fundamental investigations of ice crystal formation are badly needed to cut down the freezing time and to produce a 100 per cent crystal clear raw water ice.

Combined efforts of the crystalographer, microscopist and chemist will undoubtedly be necessary. The expenses would be fully justified for, with the fundamentals fully understood, engineers would be free to proceed with practical application.

Most important of the problems mentioned by Mr. Lang is the reduction of freezing time for the last 15 or 20 per cent of the water frozen, shorter freezing time by lower temperatures and the elimination of the last 3 or 4 per cent of opaque ice in the cake.

The first two have an important bearing on the cost of the ice produced and the last on the marketing or sale of the output. Research along these lines is badly needed. Many companies are interested in them and at the present time are carrying on scattered investigations. Investigations of this kind by practical engineers are, however, likely to be of a superficial nature based on analyses or experimental data. What is needed is a research fund which will allow the problems to be tackled by competent research scientists, not engineers, and the creation of this fund could well be undertaken by the National Association of Ice Industries.

Are Noise and Power Inseparable?

Nerve strain, mental confusion and even danger are accompaniments of excessive noise not only in industry but often in our living conditions at home, on the city streets and in our offices. All noise is not by any means a byproduct of power but people have become so accustomed to noise in connection with the operation of machinery of all kinds that it is expected wherever power is applied and this idea is a frequent handicap to the efficient use of power.

Hospitals, hotels, theaters, schools, lecture halls and offices demand quiet conditions for their occupants. This demand is met in part at least by locating the power plant serving the building at some distance and the ventilating equipment, elevator motors, electric refrigerators, organ motors, pumps and other service equipment in out-of-the-way places making them difficult of access and inefficient in application.

Frequently motors are so installed that they cause vibration of the building structure and the noise is telephoned in every direction much to the annoyance of occupants. The rush of air in ventilating ducts, the hum of transformers, the sharp putting of air compressor intakes, the exhaust of internal combustion engines and in some rare cases the drumming of boilers are all noises which accompany the generation and use of power and are frequent causes of annoyance to people who reside or work in the vicinity.

Careful design can usually eliminate or at least minimize the noise to an unobjectionable state. Cork foundations and sound proof inclosures have been effective in confining motor noise. Large ducts with easy turns are essential in ventilating systems. Silencers are being applied in industry to eliminate explosion noises. The rattle and bang of machinery in general is due principally to wear or poor design so that this noise can be greatly subdued by proper selection of machinery and adjustment of bearings.

Considerable research work will be required before all pieces of equipment will reach the stage of silence desired but continued thought and experimentation will do much to alleviate an annoying situation. Along this line, a study of work done in radio and phonograph studio construction to confine sound may help in difficult locations.

One of these days the public will class as a nuisance any device which disturbs the tranquillity of the neighborhood and the sooner industry learns the art of silent operation the better prepared we will be to meet all objections.

Those sufficiently interested to study the causes and effects of modern noises may get great help from the Noise Abatement Commission, Department of Health, City of New York, which has issued a report on its investigations in a book entitled City Noise. This report leads us to believe the commission is working along constructive, scientific lines. For example, here are a few of the questions being studied and statement of needs in the abatement of offending city noises:

We need a complete classification of noises; a tabulation of intensity geographically arranged; some scientific measurements of principal city noises together with specific recommendations as to their control or elimination.

We need a scientific statement of the effect of noise on the human being.

We should have some scientific measurements of certain types of noises and recommendations as to what constitutes the border line of reasonable, inevitable noise and unreasonable noise.

What can be done with respect to sound absorbing construction in buildings?

What experience is there in any part of the world which we may use as a basis for the elimination of unnecessary noise?

What additional laws, if any, are needed to govern the noise situation in New York?

Off Duty

IT IS A sad reflection on the intelligence of a nation of 120 millions of human beings to note the interest which no small part of that nation exhibits in the inane ravings of innumerable charlatans dispensing their wares through the agency of the radio. This, perhaps, should not be surprising when the general character of our radio programs is considered—certainly there is little worthwhile to select from; yet in much of this, in the impudent advertising hokum and atrocious programs broadcast by conscienceless radio announcers and sponsored by the gadget and nostrum manufacturers of the land, the public is quite helpless; at best it can only turn off the receiver or listen with long suffering patience. But what of the serious interest exhibited in such trash? How are we to regard the great success, as attested by hundreds of thousands of letters, of the purveyors of humbug, of those presenting daily and weekly discourses on astrology, numerology, clairvoyance and whatnot? What is the significance of the breathless interest of thousands in the horoscopes cast by Evangeline Adams and her contemporaries?

It is indeed a strange paradox—an ironical twist of fate at which the gods must shake with laughter—that radio, perhaps the greatest achievement of the human intellect, should thus become the instrument for the wholesale dissemination of ignorance, for belief in astrology is nothing more nor less than that. It is inconceivable that anybody of reasonable education in this enlightened age should take astrology seriously. As history, yes, astrology has a definite place in the realm of human thought and knowledge, and conversance with its general aspects does not imply belief; but, judging from the reactions to these radio programs on the subject and the interest exhibited by the letters of thousands of listeners, it is evident that this interest is not passive but very real.

Many, it appears, are not aware of any difference between astrology and astronomy and many are convinced that astrology as peddled by Evangeline Adams, Doris Blake and other personal advice editors and sob sisters of our metropolitan dailies, is scientific.

Now, as a matter of fact, astrology is considerably less scientific than the making of flapjacks in a Childs restaurant, or was Admiral Byrd's trip to the South Pole. Astrology is not a science—it is a pseudo science and bears approximately the same relation to astronomy that alchemy bears to modern chemistry.

Both astrology and alchemy were of value in their time—at least we like to think they were. Both served their purpose in the development of real branches of science which are of inestimable value to the world today. Astrology had its origin in the dim dawn of human history—in the imaginations and superstitions of those primitive people who first wondered at the significance of the stars. To their simple minds, knowing nothing of the physics and dynamics of the universe, it was but natural to assume that these mysterious lights in the sky should somehow be interwoven with their own destinies. While they watched the stars and studied their motions, their imaginations made up for whatever their reasoning powers lacked. And so, side by side with the development of elementary astronomy on its observational and mathematical sides, were evolved in intimate connection with it but in extraordinary imaginative forms, astrology and cosmology; the first dealing with the supposed influence of the heavenly bodies on human affairs and the second with the structure and organization of the world. Both of these pseudo-sciences were inextricably blended under priestly and literary influences with a bewildering mass of superstition and mythology, legend and invention. In the first stages both doubtless contributed powerfully to the interest and progress of real science—later they were nothing but deterrents and had to be torn away.

Thus, as a factor in the development of human intellect, astrology has a place in history but to think that any person could possibly take it seriously today is beyond comprehension and to employ the radio for the purpose of disseminating information on such pseudo-sciences is evidence as to the incompetence and irresponsibility of those who control radio broadcasting.

In his recent address as retiring president of the Institute of Radio Engineers, Lee de Forest is emphatic in his denouncement of the present state of radio broadcasting and warns against the "cancerous growth" which is relentlessly eating at the vitals of radio's usefulness and prosperity. "The insistent ballyhoo of sales talk which now viciously interrupts 70 per cent of entertainment programs even on the costly chain networks has already reduced the sum total of listening hours and the advertising from local stations has become so uncontrolled that one must wonder at the patience of a long suffering public that endures it. Yet the broadcasters take no heed and greedily sell more and more time for impudent and degrading sales talk."

To these charges by Dr. de Forest must be added that of the insult to our intelligence by the sponsoring of programs on astrology, numerology and other pseudo scientific hokum which fall far below even the "thirteen-year-old level" upon which the Federal Bureau of Education instructs radio advertisers to present their programs.

Those who are responsible for the technical development of radio—the scientists and engineers who have their lives in creating this marvel of human achievement are not unaware of these conditions and more and more are giving voice to their disgust. But despite their protests, their influence is small—the commercial world accepts their creations but disdains their advice—and every day the air becomes more filled with inane discourses as to the influence of the planet Uranus on the sales activities of realtors, brush merchants, tooth paste vendors and makers of gadgets.

Truly, if this fulfills General Harbord's conception of the purpose of radio, if this is, his idea of the dissemination of "culture and enlightenment" which so promotes international understanding, if this is the thing which is to advance the "glory and honor of our country," well, we give up. The nearest junk dealer can take our radio receiver.

Power Plant Engineering Developments and News

Enclosure for Open Frame Electric Motors

DAUN-WALTER CO., Milwaukee, Wis., announces a new electric Motor Enclosure for use on any open frame type motor to prevent the accumulation of dust, dirt and moisture on the motor.

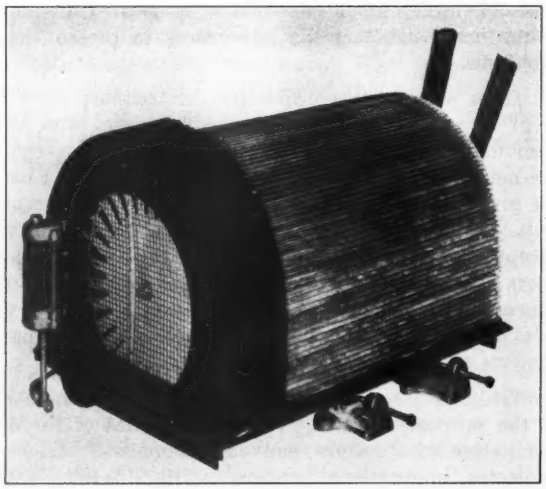
As shown in the illustration below, the enclosure consists essentially of a specially designed corrugated copper cover over the motor with steel end walls and supporting base plates. At one end of the enclosure, a cooling fan and an outside combination guard and air deflector is provided. The cooling fan is mounted on the end of the motor shaft opposite the pulley end by means of a special D-W Shaft Adapter. The Adapter can be installed in a few minutes without disturbing the motor. By means of the fan and the air deflector, a single path of outside air discharges over the outside areas of the patented deep-fin corrugated copper construction over the motor, thereby carrying off the heat from the interior developed by the motor. The base plate is of heavy gage steel of box construction in which the motor is placed and prevents the entrance of dirt, dust or moisture from below. The complete enclosure is so designed as to permit mounting on motor slide rails for belt adjustment.

The D-W electric motor enclosure eliminates all trouble arising from dirt, dust and moisture, and at the same time absorbs and radiates heat developed by the motor to a degree that keeps the temperature down to N. E. M. A. standards.

Frequent inspection is exceedingly important and provision for this is made so that it requires only a few minutes to open the enclosure completely and expose the motor for examination from all directions. This is made possible by the vertical split construction of the enclosure.

These enclosures are available for all open frame type motors, 2 and 3-phase, in sizes of 5 to 100 hp., and for d.c. motors from 5 to 100 hp.

Great saving in original cost and weight is claimed for the use of an open frame motor with the D-W enclosure as against the use of a totally enclosed frame type of motor.



D.-W. ENCLOSURE FOR OPEN FRAME TYPE ELECTRIC MOTORS

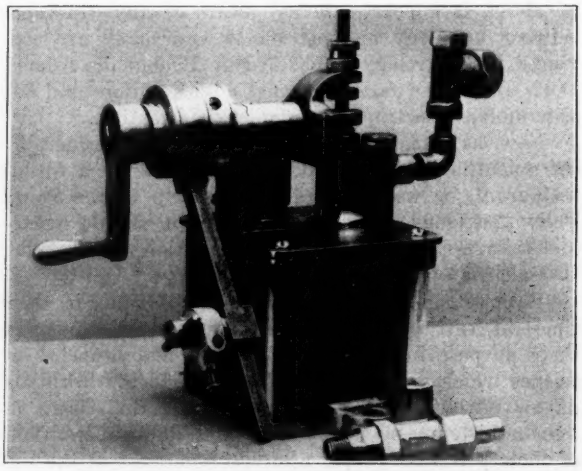
Drive for Lubricators

HILLS-McCANNA lubricators are now obtainable with either the new K-K (Kam-Klutch) drive or the ratchet type of driving mechanism, it is announced.

The principle of the Kam-Klutch is that of spring-held rollers, embodied in a housing, that work with and against the crankshaft when operating.

The mechanism comprises a right-hand part which attaches to the standard for the purpose of holding the crankshaft when on the back stroke and a left-hand part which attaches to the driving rod operating the crankshaft on the forward stroke.

The drive permits attachment to high-speed driving arms in any position within the arc of a complete circle and likewise is designed to give the lubricator greater



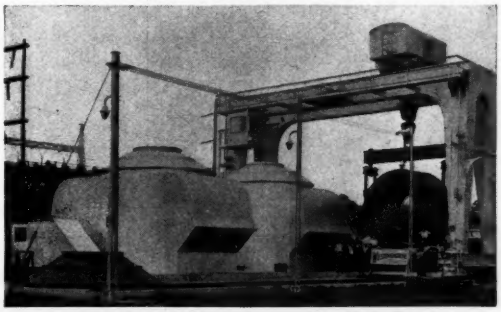
KAM-KLUTCH DRIVE FOR LUBRICATORS

speed in oil delivery when and where needed. All parts are hardened and packed in grease for trouble free operation. The Kam-Klutch is interchangeable with the present ratchet drives. Another feature is the new style charging arm or crank shaft for flushing cylinders when starting up or to increase flow when lubricator is in operation. The new device is a product of Hills-McCanna Co., 2349 Nelson St., Chicago, Ill.

Outdoor Vertical Synchronous Condensers

LOCATED AT THE great Leaside Substation of the Ontario Hydroelectric Commission is a unique installation of outdoor vertical synchronous condensers. The illustration shows the third of these condensers being installed. The fourth has since been added. It will be remembered that the delegates to the summer convention of the A.I.E.E. visited this station while in Toronto in June, 1930.

These condensers, rated at 25,000 kv-a., 500 r.p.m., 25-cycle, are located at the receiving end of the Hydroelectric Commission's 220-kv. transmission line from



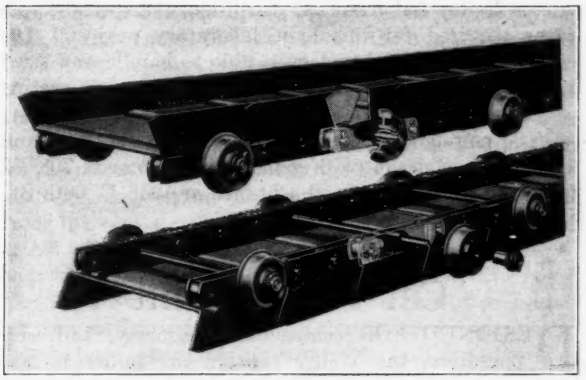
OUTDOOR INSTALLATION OF VERTICAL SYNCHRONOUS CONDENSERS AT LEASIDE, CANADA

Paugan Falls to Leaside. The vertical design has a particular advantage because it allows the exciters and controls to be indoors. These exciters and even the main rotors may be lowered into the chamber below for inspection. Air brakes provide prompt stopping.

The weight of a complete unit is approximately 210 tons. The stator frame of the main unit complete with iron and coils weighs 84½ t.: the rotor of the main unit, completely assembled on the shaft, weighs 75 t. The field coil weighs nearly 2 t. The overall height of the unit from the bottom of the speed relay to the top of the housing is 34 ft. The maximum width of the unit over the housing, exclusive of the ventilating extensions, is 19½ ft. The Canadian Westinghouse Co. of Hamilton, Ontario, built and installed these machines.

"Leak Proof" Apron Conveyor and Feeder

NEW DESIGN of apron conveyor and feeder, known as Leak Proof, incorporating equalizing saddles and renewable outboard rollers and bushings, has just been standardized by The Chain Belt Co. of Milwaukee, Wis. This conveyor will be furnished in four sizes,



EQUALIZING SADDLES AND OUTBOARD RENEWABLE ROLLERS ON NEW CONVEYOR

three 9-in. pitch and one 12-in. pitch for various conditions. The great majority of the parts will be carried in stock so that prompt deliveries can be made. The sides of the conveyor are welded to the double beaded apron and so designed that there are no openings at the articulating points. This is to allow the conveying of fine material, such as fine coal, without spilling.

It will be noted that the load of the conveyor is carried entirely on outboard rollers which rotate over case-hardened steel sleeves mounted on through rods. These rollers and bushings are made to be easily removable without disturbing the chain or any part of the conveyor when repairs are required. This arrangement of outboard rollers is intended to prolong the life of the chain, as the chain rollers are thus relieved of the carrying loads of the conveyor and there is no movement of the chain rollers except a partial turning as the rollers engage the sprocket teeth at the terminals. Aprons are attached to the saddles which are mounted between chain side bars, to impose the load equally on both side bars and also to make it possible to remove an apron easily, if desired, without disconnecting any other part of the equipment.

The equalizing saddle type conveyor with outboard rollers was designed especially to handle material containing a considerable portion of fines and also where this material is abrasive.

Steel to Be X-Rayed in Chicago Laboratory

X-RAYING STEEL, iron and metal up to a thickness of 4½ in. is the service rendered to industry by the newly organized Claud S. Gordon Steel X-Ray Laboratory of Chicago. Patterns, tools, dies, castings, raw material and all shapes and sizes of steel and iron will undergo the microscopic scrutiny of this most powerful of all X-Ray equipment. Inherent defects and bugs will be uncovered just as in the X-Raying of teeth or parts of the human body, a science highly developed in the medical and dental professions.

The company is making this new service available to all industries using steel in manufacturing. This steel X-Ray Laboratory is the only one of its kind west of New York. "Metallurgical radiography" is the scientific term applied to this new science. The General Electric X-Ray Corporation of Chicago (formerly the

Victor X-Ray Laboratories) furnished the special apparatus required for this huge laboratory project. The equipment of the laboratory is able to handle any sized piece of metal from the smallest to the largest casting or pressure shell.

The new laboratory is located at Western Ave. and 15th Place, Chicago, with general city offices at 708 W. Madison St., Chicago, and a branch at 1988 E. 66th St., Cleveland, Ohio.

Car Pulling Unit

DESIGNED FOR compactness, economy, and easy operation, the Weller capstan car puller is now available in an improved design, shown herewith. Regularly built in three sizes to handle from one to six 80-t.

IMPROVED CAR PULLER IN OPERATION

cars, this electrically operated unit is self-contained, weatherproof and designed to pull cars or trucks, at any angle. It is made by the Webster and Weller Mfg. Cos., Chicago, Ill.

Turbidimeter for Sulphur or Sulphate Determinations

BURGESS PARR TURBIDIMETER, recently announced, is an instrument based upon the Parr Sulphur Photometer and designed to provide great accuracy, easy operation and speed. It has been applied successfully to the measurement of sodium sulphate in boiler waters, a measurement of extreme importance in guarding against caustic embrittlement. It also finds use in the analyses of fuel for sulphur, being an accessory, in this instance, to the oxygen bomb calorimeter, the Burgess-Parr peroxide calorimeter or the Burgess-Parr sulphur bomb.

The Turbidimeter consists of a bakelite-walled container having an optical glass bottom, a plunger tube of similar construction, a mechanism for altering the distance between the bottoms of the two tubes and an eye-piece tube using a soft rubber shield, all mounted upon a lacquered metal base containing an electric filament lamp with a rheostat and voltmeter for controlling the lamp voltage. In operating the Turbidimeter, the turbid solution (produced by adding barium chloride crystals to the boiler water or oxygen bomb washings) is poured into the containing tube. The plunger tube and eye-piece tube are set in the proper position, the electric lamp is regulated at the proper voltage and by means of a gear and rack mechanism, the plunger tube is raised until the filament of the lamp can no longer be seen from the eye-piece. The reading in millimeters of solution is then made from the instrument scale and, by referring to a chart provided with the instrument, the quantity of sulphur or sulphate can be determined. Check determinations can be made within a few seconds to insure accuracy.

The outstanding advantage claimed for the instrument is the speed with which sulphate determinations can be made. A complete determination of sodium sulphate in boiler waters can be made within three or four

BURGESS PARR TURBIDIMETER

minutes, it is stated, and the same speed can be obtained in making sulphur determinations from oxygen bomb washings or peroxide bomb fusions. The simplicity of the Turbidimeter and its ease of operation make it an excellent instrument for power plant use, it is claimed, especially as it does not require the services of a trained chemist. It is made by the Burgess-Parr Co., Chicago, Ill.

ON PADLOCKS exposed to winter weather water often trickles down the shackle and freezes. The Associated Engineers Co., Chicago, Ill., has developed a metal gasket cap to protect the interior mechanism of the lock from water that falls on the top of the lock. The metal cap is made in four parts: two sleeves which project upward around the shackle openings in the casing and two annular aprons which project down over the sleeves, to divert water from the apron to the exterior of the lock. This device is designed for attachment to any padlock, not only to improve its appearance but also to assure its operation in any weather by keeping the inner mechanism dry, thus avoiding necessity for thawing or forcing frozen locks on outdoor switching equipment, tool boxes and similar equipment.

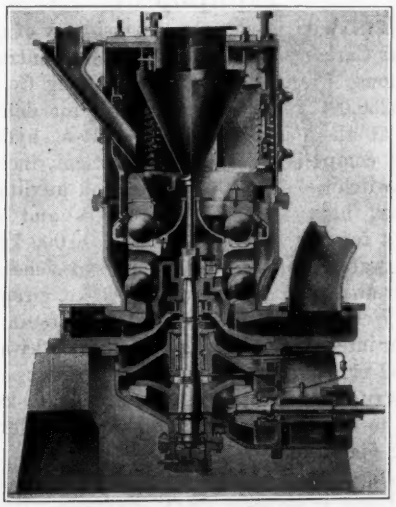
INCREASE of belt wrap around pulleys by means of properly installed idlers decreases the tension needed to transmit a given power, hence increases belt lift, decreases shaft friction and the amount of upkeep labor needed.

New Pulverizer Uses Two Rows of Grinding Balls

AN AIR SEPARATION ball mill known as the new Type B pulverizer has recently been placed on the market by Fuller Lehigh Co., Fullerton, Pa. Essentially the Type B mill consists of a top or separator section; an intermediate or pulverizing section and a base or drive section.

Top section is of heavy steel plate and cast-iron construction and contains the classifying cone, coal spout and the mechanism for adjusting the grinding pressure. The intermediate section is of heavy section cast iron with carefully machined flanges to which are fastened the top and base sections. The grinding elements, coal basket and driving yoke are mounted in the intermediate section.

Base or drive section is also of heavy section cast iron designed to provide a rigid support for the mill.



CROSS SECTION OF FULLER LEHIGH CO., TYPE B PULVERIZER

This section encloses the air distributing chamber, main and thrust bearings, drive shafts and gears and the force-feed oiling system.

Grinding elements consist essentially of two rows of large diameter balls, two stationary and one rotating grinding rings. The rows of balls, one row mounted above the other, are separated and propelled by the rotating ring which is driven by and floats on the main driving shaft. Both the stationary and rotating grinding rings are made to gage in order to insure interchangeability. Grinding pressure between the balls and rings is applied and kept uniform by externally controlled steel springs mounted in the top section.

The main driving shaft is supported by a self-alining heavy-duty Rollway thrust bearing. The mill is so designed that all thrust from grinding is absorbed by the heavy lower casing. All bearings and gears are effectively sealed from the grinding zone and are lubricated by an automatic force-feed oiling system.

Operation of a Type B Pulverizer is quite simple. Raw coal, drops through the feed spout onto a rotating cone inside the upper row of grinding balls. After the coal is ground in the upper row of balls, practically all of it is fine enough to pass through the annular opening formed by the intermediate grinding ring and the coal basket. Fines are entrained and carried upward by the air stream, while the coarse particles of coal drop into the lower row of grinding balls for further pulverizing. As the pulverized coal reaches the top of the mill coarse particles, carried upward with the fines, are rejected from the coal stream by either the force of gravity or action of the classifier. The coarse particles return to both rows of grinding balls for further pulverizing. The Type B Mill is well adapted to the use of preheated air as a separating medium so that it can be adapted to installations where drying within the mill is to be used, eliminating the expense of independent drying and conveying equipment.

Type B pulverizer is simple to control because only a few adjustments are needed for change of boiler output. The mill is particularly well suited to serve both large and small direct-fired boilers including those units which have rapidly fluctuating industrial loads. It is equally well adapted to the requirements of the storage system of pulverized coal firing. Type B pulverizers are built in capacities up to and including 40 t. per hr.

Small Circuit Breakers for House Circuits

FOR THE PROTECTION of electrical circuits in the home and for providing at the same time convenient means for restoring service after a circuit has been overloaded and subsequently opened, a combined switch and circuit protector has been developed by the Westinghouse Electric and Manufacturing Co. The use of this device eliminates all dependence upon fuses for circuit protection and avoids the inconveniences of replacement attending their use.

This device can be operated as an ordinary "off" and "on" switch to control the circuits as desired and, in addition, it has built into it a trip mechanism which causes the switch to open if the current exceeds the maximum for which it has been set.

The tripping action is not instantaneous, however, but the time of operation of the tripping mechanism is in inverse ratio to the amount of current passing through the device. Thus a small overload, say 10 per cent, takes about half an hour to trip the breaker, but this period of half an hour is considerably less time than it would take for the small overload of 10 per cent to overheat the wiring seriously and cause any damage. As the current increases, the time of operation of the trip decreases, always protecting the wire with an adequate margin of safety. A short circuit causes the device to open the circuit almost instantaneously.

It has been recognized for several years that the loads on branch circuits in homes are becoming much heavier. Only a few years ago, the principal use of electricity was for lighting; wiring was installed with that idea in mind, and the wire comprising the branch circuits was practically never loaded near its rated capacity; the fuse was seldom called upon to operate. But when heating appliances, motor driven appliances and portable decorative lamps of all kinds became common, the situation changed. Now the circuits are asked to

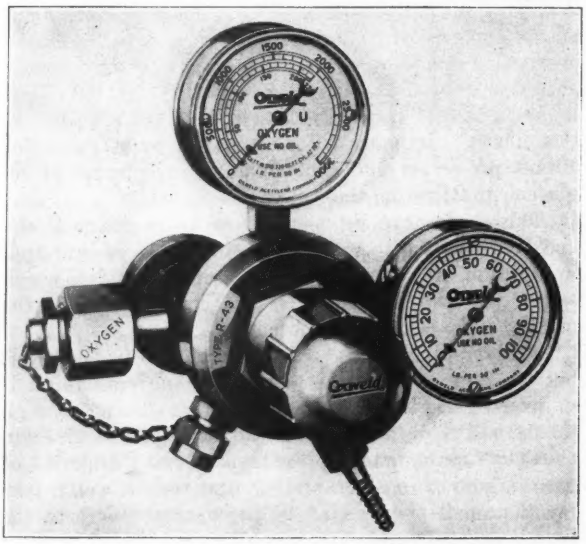
carry heavier loads and excessive currents are more frequently causing fuses to perform their proper function.

Because of the inconvenience of replacing blown fuses, people are tempted to use fuses rated at more than the permissible rating of the circuit or to bridge the fuse with a coin or other piece of metal. This situation has led to the demand for a small circuit breaker to protect branch circuits.

The switch is of the toggle type with the fixed center mounted on a swinging arm. This arm is ordinarily latched under a catch on the bi-metallic thermal overcurrent unit. As long as this arm remains latched under, the switch operates as any other toggle switch. As the current passing through the thermal unit increases, the bimetal, being composed of two metals of unequal coefficients of expansion, bends more and more until, when the current exceeds a certain limit, it releases the latch; the end of the toggle moves out of line; and the toggle promptly collapses and opens the switch. In order to prevent excessive arcing, the Westinghouse Deion principle of arc interruption is employed: Two slotted steel plates are mounted above the fixed contact, and, when the breaker opens, the arc is drawn in the slots and extinguished immediately.

Two-Stage Oxygen Regulator

To MAINTAIN a constant line pressure free from any fluctuation, a most desirable condition for good results



TYPE R-43 OXYGEN WELDING REGULATOR

in oxwelding, the Oxweld Type R-43 oxygen welding regulator, recently introduced by Oxweld Acetylene Co., New York, has been designed to guarantee such freedom from fluctuation by means of a system of two-stage pressure reduction. This two-stage reduction is accomplished through two separate and independent sets of diaphragms, valves and springs. The full cylinder pressure of 2000 lb. enters the regulator through a stem-type valve and is controlled by the first stage diaphragm. In this stage the pressure is reduced to less than 250 lb. per sq. in. This pressure will be constant for any one regulator, but varies somewhat with different regulators. The pressure here is non-adjustable.

The oxygen then passes from this first reduction assembly to a second stem-type valve and diaphragm assembly where the pressure is reduced to the working pressure desired by the operator. This pressure is regulated by the operator by the adjusting screw and any operating pressure may be obtained without fluctuation, it is stated.

Instead of the usual handle-type pressure adjusting screw found on all other Oxweld regulators, there has been substituted a screw with a ribbed cap. This change in external design is intended not only to present a neater and more compact appearance but also to avoid the possibility of breakage as there are no projections on the handle to be bent accidentally. This new type adjusting screw is of smaller diameter than the body of the regulator itself, so that it is easier to pack for transportation from one job to another.

$250,000 Order for Switchgear Equipment

NEW KANAWHA POWER CO., a subsidiary of the Union Carbide & Carbon Corp., has awarded a contract to the Westinghouse Electric and Manufacturing Co. approximating $250,000. This contract calls for delivery and erection at the customer's 120,000-kv-a. hydroelectric station of complete switchgear equipment, including an 8-panel switchboard, a 10-panel station auxiliary board and 69-kv. high tension oil breakers and switching equipment for the control of the four 30,000 kv-a. Westinghouse waterwheel generators ordered some time ago. All major switching is done on the 69-kv. circuits utilizing the Westinghouse Deion grid oil circuit breakers, having an interrupting rating of 1,000,000 kv-a.

The 69-kv. equipment is located outdoors, embracing a steel structure substation. A double 69-kv. bus is provided to assure ease of maintenance and flexibility of switching operations.

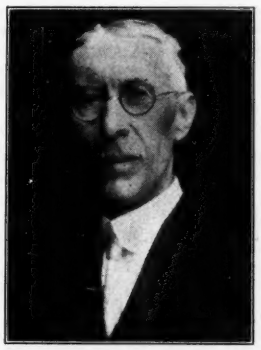
It is stated that good progress is being made in the boring of the three-mile, 28-ft. diameter tunnel which will deliver water to these generators in the plant located near Gauley Junction, West Virginia.

The complete station, including generators, outdoor switching equipment, auxiliary service, and so on, is controlled from a comparatively small and compact switchboard control room. All switchboard panels are of steel and the switchgear, it is claimed, represents the latest features of modern switchboard practice.

THE UNITED STATES CIVIL SERVICE COMMISSION open competitive examinations for an associate engineer, $3200 to $3700 a year and an assistant engineer, $2600 to $3100 a year. Applications for associate engineer (optional branches—architectural, construction, heating and ventilating and ordnance) and assistant engineer (optional branches—aeronautical, architectural, electrical, heating and ventilating, mechanical, structural, construction and fire prevention) must be on file with the Commission at Washington, D. C., not later than April 1, 1931. Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

Lamme Medal Awarded to W. J. Foster

ANNOUNCEMENT HAS JUST been made of the award of the Lamme Medal of the American Institute of Electrical Engineers to Dr. William J. Foster of Schenectady, N. Y., "for his contributions to the design of rotating alternating-current machinery." It will be presented to him at the Summer Convention of the Institute which is to be held in Asheville, N. C., June 22-26, 1931. The Lamme medal was founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co., who died on July 8, 1924, to provide for the award by the institute of a gold medal (together with a bronze replica thereof) annually to a member of the American Institute of Electrical Engineers, "who has shown meritorious achievement in the development of electrical apparatus or machinery" and for the award of two such medals in some years if the accumulation from the



DR. WILLIAM J. FOSTER

funds warrants. A committee composed of nine members of the institute awards the medal.

William James Foster, Sc. D., consulting engineer, retired, General Electric Co., was born in Argyle, N. Y., September 17, 1860. His college preparatory work was done partly alone with borrowed textbooks and partly at an academy and a boarding school. After graduating from Williams College with the A. B. degree in 1884, he remained a year for advanced work in mathematics. During the next five years, he taught high school subjects and made an intensive study of physics. The degree of Master of Science was conferred upon him by Cornell University in 1891, following a year of graduate study.

In the summer of 1891, Dr. Foster began his engineering career in the Thomson-Houston Works in Lynn, Mass. He was assigned to development work on induction motors early in 1892 and to similar work on synchronous converters a few months later. On October 1, 1892, he became assistant engineer, and began at that time a close association with Dr. H. G. Reist which continued for 37 years.

Beginning in 1893 and extending through several years, his association with Dr. Steinmetz was very close. During this period, Dr. Foster assisted in general improvements, developed retardation tests, and originated tests for measuring short circuit losses. His drafts of test methods involving heat runs, overloads, temperature rises, etc., were submitted through Dr. Steinmetz to the Committee on Standardization of the A. I. E. E. and adopted as standards.

He has had general charge of the electrical designs of alternating-current rotating machines, built by the General Electric Co., during most of his engineering life. For about 25 yr., beginning in 1895, he made practically all the calculations on the most important generators that were built by this company and installed in all parts of the United States and in many foreign countries. His energy was invariably directed to securing designs as free from losses as possible and efficiencies higher and temperatures lower than promised. Early in this period, windings were devised and insulations developed for potentials from 9000 to 18,000 v. Many of the early high voltage machines—steam engine driven, hydraulic, and steam turbine—have been replaced by units with more efficient prime movers, but many of the hydraulic vertical generators are still in service.

Mr. Foster has contributed important papers to the publications of the A. I. E. E. and other technical journals.

He joined the institute in 1907, and was transferred to the grade of Fellow in 1916. He served as a member of the Committee on Electrical Machinery for ten years, and was chairman during the year 1928-29.

His other memberships include Phi Beta Kappa and the American Association for the Advancement of Science.

Death of Sir Charles Parsons

ON FEBRUARY 11, Sir Charles Parsons, K. C. B., inventor of the reaction steam turbine and considered one of the world's foremost engineers, died suddenly aboard the liner Duchess of Richmond, while on a pleasure cruise to the West Indies.

He was born in London, England, in 1854, the son of the Earl of Rosse, who was a scientist of distinction and at one time president of the Royal Society. The early education of Sir Charles was supervised by his father, who encouraged him in the study of science. Later he attended St. John's College at Cambridge and became interested in rotary engines and in the possibility of designing a steam turbine.

In 1883 he became a member of the engineering firm of Clark, Chapman, Parsons & Co. at Gatehead-on-Tyne and the following year built his first steam turbine. This was a small double-end, parallel-flow machine operating at 1800 r.p.m. and driving a generator rated at about 4½ kw. In 1889 his connection with Clark, Chapman, Parsons & Co. was ended and as he was cut off from his original patents which remained with the firm, he turned his attention to radial flow turbines and established the firm of C. A. Parsons & Co., of which he was the head at the time of his death. In 1894 he recovered his patents, built the first steam turbine driven ship and from that time on the number and variety of his inventions and engineering interests increased rapidly. He was made a fellow of the Royal Society in 1898, was president of the Institute of Marine Engineers in 1905-06, and of the British association in 1919-20. He was awarded the Franklin medal in 1920 and the Copley in 1928.

News Notes

THE FULLER LEHIGH CO. announces that the general offices of the company are transferred from Fullerton, Pa., to 85 Liberty St., New York, N. Y. The manufacturing operations formerly carried on at Fullerton are transferred to Barberton, Ohio.

CONDUIT ELECTRICAL MFG. CORP. announces a new indoor oil circuit breaker with enclosed type mechanism and all poles in one tank, known as type DR-25. This breaker offers the features of non oil throwing, greater clearances, quick clearing operation, small space requirements and provision for venting gases.

It is furnished three or four-pole, manually or electrically operated for 600, 800 and 1200 amp. at 15,000 v. Estimated interrupting capacity 2500 amp. at 15,000 v.

HOLDERS OF CERTIFICATES of indebtedness for erection and installation of the municipal electric plant in Shelbyville, Ill., have received $86,494 from the Central Illinois Public Service Co. in payment upon principal and interest due upon the plant, concluding negotiations between the utilities corporation and the city for purchase of the city-owned plant.

ILLINOIS POWER CO. is contemplating expenditure of $250,000 upon plant and line expansion in DeKalb, County, Illinois, according to A. D. Mackie, vice-president of the company, in connection with negotiations for inter-connections with the Illinois Northern Utilities Co. at Genoa and with its generating plant at Belvidere. Additional boiler equipment at the DeKalb, Ill. plant, new auxiliary and transformer equipment, and about $75,000 for pole and wire expensions, chiefly rural, in the district, are included in the improvement budget.

ILLINOIS TESTING LABORATORIES, Inc., 141 W. Austin Ave., Chicago, Ill., announces the appointment of Ernest H. Du Vivier, 30 Church St., New York City, its representative in Metropolitan New York and northern New Jersey and F. W. Fernald of 335 Fifth Ave., Pittsburgh, Pa., as its representative in Western Pennsylvania and West Virginia for its line of portable and stationary pyrometers, resistance thermometers and other measuring instruments for industrial uses.

AFFILIATED ENGINEERING COMPANIES, Ltd., announce the removal of their Montreal offices from the Southern Building to Suite 1606, University Tower, 660 St. Catherine St., W., on March 1, 1931.

EIGHTY-FIRST MEETING of the American Chemical Society will be held in Indianapolis, Ind., March 30 to April 3. More than 1500 scientists are expected to attend the divisional and general sessions.

BILL TO ESTABLISH a state public service commission with power to regulate all public utilities in Iowa, except telephone companies, has been introduced in the state legislature by Frank W. Elliott, Davenport. The proposed commission would abolish the present railroad commission but provides that the present three commissioners become members of the new utilities commission with two other appointees by the governor. The attorney general's office is drafting another public utility regulatory measure which it is reported will be even more far-reaching in its scope than the Elliott bill. The Elliott bill empowers the commission to determine just and reasonable rates for utility service; enforce standards of equipment and service; establish, at any time desired, valuations of utility assets; determine necessity of new construction or extension facilities and issue such permits; audit and inspect books of utility companies at any time. The bill specifies that only gas lighting and heating, electric light, steam-heating, waterworks, rail and motor transportation and pipe line companies come under its jurisdiction.

ACTING UPON recommendations of Governor Dan Turner in his inaugural message, the Iowa house of representatives has adopted Leonard Simmer's bill authorizing municipalities to pay for public utilities plants out of future earnings. The measure was passed by a 76 to 23 vote after four days' debate in which effort to send it back to committee was defeated 43 to 58 and proposal of F. W. Elliott, Scott County, to amend it to provide that rates, terms of contract and cost, be submitted to referendum of the citizens, was defeated. The Wapello County legislator, who introduced the measure, added a provision calling for vote of the people on establishment of a municipal plant. Under the bill, cost and rates decisions were rested in the city council after public hearing on the question. The commission bill in the Iowa senate is sponsored by E. R. Hicklin, Louisa County.

GIFFORD-WOOD CO., Hudson, N. Y., announces its absorption of the C. W. Hunt Co., Inc., West New Brighton, Staten Island, New York. The Gifford-Wood Co. will manufacture and sell the complete line of equipment formerly produced by the C. W. Hunt Co., Inc., and will operate that company as a division of the Gifford-Wood Co. All records, drawings, patterns, stock and machinery for manufacturing these products have been transferred to the main plant of the Gifford-Wood Co. at Hudson, N. Y. Sales and service will be handled through the Gifford-Wood sales organization at its regional offices in the Graybar Building, Lexington Ave. and 43rd St., New York City, and at 565 West Washington St., Chicago, Ill.

SALES EXECUTIVES of Worthington Pump & Machinery Corp. from all over the United States, assembled for annual meeting in Harrison, New Jersey, on February 9, for a three-day session. At this meeting, H. C. Beaver, formerly executive vice-president of Rolls-Royce of America, was introduced as a new vice-president. He will devote his efforts principally to the administration of the Sales Department. As of the same date, E. E. Yake, was advanced to the office of vice-president to direct Manufacturing and Engineering as formerly. The corporation reports a most successful year, in spite of the economic conditions, having made 97 per cent of its Sales quota. This quota was the same as that set for 1929.

L. P. Spillan, sales manager of the Shovel and Crane Division of Link-Belt Co., Chicago, announces the Stockland Equipment Sales Co., 2628 University Ave, S. E., Minneapolis, Minn., as shovel-crane-dragline agent in Minnesota (excepting a few counties around Duluth), and part of Central West Wisconsin. J. W. Chapman is general manager of Stockland Equipment Sales Co.

LINK-BELT CO., Indianapolis, Ind., announces that the following distributors of Link-Belt automotive timing chains have been appointed for their respective territories: Automotive Bearings & Equipment Co., 713-716 Sycamore St., Cincinnati, O.; Cartier & Bulman, 2613 Baker Ave., Bell, Calif.; Taft Auto Specialty Co., 305 Center St., Taft, Calif.; Roper Auto Part Co., 2554 Randolph St., Hunting Park, Calif. Link-Belt Co., Philadelphia, Penna., announces that Joe C. Tucker, Morganfield, Ky., has been appointed agent in his territory for Link-Belt portable loaders.

THE OHIO EDISON CO., Youngstown, Ohio, has authorized a fund of about $7,000,000, for extensions and improvements in plants and system during 1931. The work will include the construction of additional transmission lines, with completion of high-tension line from generating plant at Toronto, on the Ohio River, to Akron and vicinity, estimated to cost about $2,000,000, with switching and substation facilities, and of which amount approximately $700,000, has been expended; a fund of $200,000, will be used for the construction of a new district central steam heating plant at Akron, and about $287,000, for the erection of two additional stories on the Ohio Edison building in that city. At Youngstown and vicinity, approximately $3,400,000, will be expended for expansion in substations, lines and other operating facilities; at Springfield, about $459,000, will be used for similar expansion. The company is an interest of the Commonwealth & Southern Co., New York.

THE VIRGINIA ELECTRIC & POWER CO., Richmond, Va., has arranged an appropriation of about $4,000,000, for extensions and improvements in plants and system during the coming year, including transmission lines, power substation expansion and distributing systems. Of the sum noted, approximately $1,000,000, will be used in the Richmond district, including Petersburg, Roanoke Rapids, Fredericksburg and vicinity; a new 13,000-volt transmission line will be constructed from the Richmond power station, Twelfth Street, to the Cedar substation at Fulton, reported to cost about $35,000; a new power line will be built on Summers Avenue, to cost about $18,000. About $30,000, will be used for transmission line extensions for rural service.

MUNICIPAL POWER DEPARTMENT, Winnipeg, Man., officially known as the City of Winnipeg Hydro Electric System, is carrying out an expansion program in the local central steam-heating plant and system, for which a fund of $450,000 recently was authorized. It is understood that plans are now being considered for an additional sum of $1,000,000, to carry out further development of the plant and system, a sizable portion of which will be utilized for the installation of steam lines in the suburban territory. The power plant operates economically on lignite fuel mined in Western Canada, and now furnishes extensive service throughout the metropolitan area, bringing reductions estimated from 15 to 40 per cent in fuel bills for consumers; about 200 buildings are securing service from the station. As a further development, the city proposes to utilize hydroelectric power for steam generation, employing a portion of the new municipal enterprise at Slave Falls, now under way, and which will represent a gross investment of close to $7,000,000. The municipal heating plant at Winnipeg was inaugurated in 1925, and is the first plant of its kind in Canada.

WILLIAM C. DICKERMAN, chairman of the board of McIntosh & Seymour Corp., has announced the retirement of A. E. Ballin, effective February 1, 1931, as president and director of the corporation. At a meeting of the board of directors of McIntosh & Seymour Corp., held February 2, 1931, R. B. McColl was elected president and director of the corporation.

HENSZEY DE-CONCENTRATOR CO., Watertown, Wis., announces the appointment of Leo. J. Schaedle, 950 Dierks Bldg., Kansas City, Mo., as sales representative for that territory.

MORSE CHAIN CO., Ithaca, N. Y., manufacturer, has just completed a most enthusiastic sales convention, according to F. C. Thompson, vice-president and general manager. Salesmen from the entire country were called in to spend three days at the main plant at Ithaca, leaving there by special car for a one-day session at Detroit, where the specialties recently developed were presented to them. Officials of the Borg-Warner Corp., of which the Morse Chain Co. is a subsidiary, were in attendance at a banquet which marked the close of the convention.

TESTS of broad interest in several phases of fuel utilization marked the 6 mo. field work of the course in Fuel and Gas Engineering at the Massachusetts Institute of Technology now brought to a close. At the Tide Water Oil Co.'s refinery in Bayonne, New Jersey, gas and oil-fired crude stills, solution stills and cracking coils were studied.

Efficiencies of a gas producer and a billet reheating furnace were determined at the Lackawanna Plant of the Bethlehem Steel Co. and extensive tests were made on the dry quencher and Koppers liquid purification system at the gas plant of the Rochester Gas & Electric Corp. The 1400-lb. boilers and turbines at the Edgar Station of the Edison Electric Illuminating Co. of Boston were also subjects for part of the test work.

The field work follows a year's study in theory of combustion, natural and manufactured fuels, power development, furnace design, utility economics, fluid flow, heat flow and kindred subjects in the graduate course at Massachusetts Institute of Technology.

FOR THE ANHEUSER-BUSCH plant under erection by Stone & Webster Eng. Corp. at Old Bridge, N. J., a boiler plant will be erected to furnish process steam. Two 323-hp. boilers designed for 170 lb. pressure to operate at 125 lb. will be installed. These boilers will be fired by mechanical atomizing oil burners. In addition to the boilers, a steam accumulator of 7500 lb. capacity will be installed. It is planned to begin construction on the boiler plant about the middle of March in order that it may be ready for operation by September 1 of this year.

GENERAL REFRACTORIES CO. of Philadelphia, Pa., announces the appointment of the West Allis Fuel & Supply Co. of West Allis, Wis., as distributors of its products. These distributors will operate in Milwaukee and Waukesha Counties.

IT IS PLANNED, pending ratification by stockholders of the respective corporations at their annual meetings February 17, that the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., will acquire all the assets and business of the Time-O-Stat Controls Corp., the latter organization to be operated as a division of the Minneapolis Company.

DR. RALPH B. KENNARD, formerly head of the Physics Department of Robert College, Istambul, has been appointed a research associate of the Bureau of Standards, Washington, D. C., for research work in accordance with the provisions of the Luther B. McMillan Fellowship.

The privilege of establishing and maintaining this fellowship as a memorial to the late Luther B. McMillan was accorded the Johns-Manville Corporation by the Director of the Bureau of Standards shortly after the untimely death, in August, 1929, of Mr. McMillan, consulting engineer for the company and a pioneer in research in heat transfer problems.

The associate research work to be conducted by Dr. Kennard will cover fundamental problems involved in the transfer of heat between solids and fluids. Dr. Kennard, before joining the staff of Robert College, was connected with the University of Chicago, where he received the doctors' degree in physics. His special field of study has been in thermodynamics, kinetic theory, and electricity and magnetism. His publications have dealt with kinetic theory phenomena in high vacua.

UNITED CONVEYOR CORP., Chicago, Ill., announces that it has just completed the formation of its Canadian company, United Conveyor Corp. of Canada, Ltd., Queen St., East, Toronto, Ont.

GIRTANNER ENGINEERING CORP. of New York has become part of the Wilbur G. Hudson Corp. at 30 Church St., New York, but will continue to operate under its own name as heretofore. W. W. Burden is president; Alexander Girtanner, vice-president and general manager, and J. A. Robinson, chief engineer. The same personnel has been retained and with the addition of the engineering and sales staff of the Wilbur G. Hudson Corp., the company has broadened its activities and is now engaged in experimental and development work that will be reflected in new equipment lines in the near future. The combination offers a complete service in material handling installations of all kinds.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examinations for principal engineering inspector-superintendent and senior engineering inspector-foreman, applications for which must be on file with the commission at Washington, D. C., not later than March 25, 1931. These examinations are to fill vacancies in the Bureau of Public Roads, Department of Agriculture, for duty in the field. Entrance salaries for principal engineering inspector-superintendent range from $2300 to $2900 a year; for senior engineering inspector-foreman they range from $2000 to $2600 a year. Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

Books and Catalogs

TREATMENT of Water for Ice Manufacture, by Dana Burks, Jr. Published as Bulletin 219 by the Engineering Experiment Station of the University of Illinois, Urbana, Ill.; size, 6 by 9 in., 112 pp., paper bound; price, $0.60.

General survey of raw water sources available throughout the United States for the production of manufactured ice, and the development of methods of water treatment whereby each of these water supplies may become available for the production of the highest quality ice in completely electrified plants. As a result of the investigation two distinct methods were developed whereby any characteristic sodium bicarbonate water source may be used in the production of marketable manufactured ice. The first is based upon definite modifications in present manufacturing practice, places particular stress upon obtaining greater efficiency of air agitation during the freezing process by means of a new type of ice can, and makes no attempt to reduce the concentration of salts dissolved in the water prior to the freezing operation. The second introduces a new method of chemical water treatment prior to the freezing operation, whereby the total salt concentration of the water may be reduced to such an extent that standard operating conditions and equipment may be utilized. A few copies are available for free distribution by the Engineering Experiment Station, Urbana, Illinois.

IN A RECENT CATALOG No. 469, Buffalo Unit Heaters are described. Highboy and Lowboy units, their construction and operation are discussed, also the Wetboy unit for washing the air before it is heated. Model B Breezo-fin Heater and Gas Unit Heater are also described in detail. Data are given on choosing the right type and size of heater for various application.

NON-CLOGGING PUMPS of the open-shaft type for sewage handling and drainage in Municipal sewage disposal plants, lift stations, building and industries are described in new bulletin No. 126 by Chicago Pump Co., 2336 Wolfram St., Chicago, Illinois.

KNOPP PHASE SEQUENCE INDICATOR for determining the phase rotation of a polyphase circuit is described in a new bulletin by Meter Devices Co., Canton, Ohio.

DETAILS OF REFRIGERATING and ice making equipment as supplied in several large skating rinks are described in bulletin No. 198-A, issued by Frick Co., Waynesboro, Pa.

FIRITE STOKERS is the title of a new 24-page illustrated catalog published by the Hoffman Combustion Engineering Co., 410 Ford Building, Detroit, Mich. The catalog contains pictures of several suggested layouts with various types of boilers from 70 to 700 hp.

ECONOMICAL AND AUTOMATIC heating and schools is covered in an illustrated bulletin just published by Detroit Stoker Co., 3d floor, General Motors Bldg., Detroit, Mich. The illustrations picture the wide variety of schools and the different types of Detroit stoker used to solve their varied heating problems.

"A CRANE WITHOUT A 'YOUNGSTOWN' is as risky as a boiler without a safety valve" is the title of a four-page leaflet just issued by the Electric Controller & Mfg. Co. of Cleveland, Ohio. This leaflet describes the application of the Youngstown Safety Limit Stop to crane hoists.

E. Y. SAYER ENGINEERING CORP., 152 W. 42nd St., New York, N. Y., is issuing a pamphlet describing its service in investigations, design and superintendence of construction for all classes of structures and plant equipment.

Power Plant Construction News

Ariz., Globe—City Council, Globe, is considering installation of pumping machinery and auxiliary power equipment in connection with extensions and improvements in municipal water works to cost about $30,000.

Ariz., Williams—City Council, Williams, is said to be planning installation of pumping machinery and other mechanical equipment in connection with a new water supply system to cost over $175,000. A. A. Weiland Engineering Co., Thatcher Building, Pueblo, Colo., is engineer.

Ark., Blytheville—The Arkansas-Missouri Power Co., Blytheville, is said to be arranging a bond issue of $500,000, portion of proceeds to be used for extensions and improvements in plants and system, including hydroelectric power development on the Spring River, Fulton County, to cost close to $250,000. Company engineering department will be in charge.

California, Pasedena—The Municipal Light and Power Department, Pasedena, is considering the installation of additional equipment in municipal power plant, including a 25,000 kw. steam turbo unit, estimated to cost close to $400,000.

Calif., San Francisco—The California State Harbor Commission, Ferry Building, plans extensions and improvements in cold storage and refrigerating plant on the waterfront, estimated to cost about $100,000. F. G. White, address noted, is chief engineer.

Calif., Tulare—The Tulare Utility District, Tulare, is considering a bond issue of $3,000,000, for a municipal electric light and power plant, and distributing system. Engineering department will be in charge.

Conn., Bristol—The Connecticut Light & Power Co., Hartford, Conn., is planning construction of a steam power plant on Riverside Avenue, Bristol, for central steam heating service in the business district, reported to cost over $100,000, with equipment. It will replace an existing station on Highland Court, which will be dismantled. Harold A. Hayden, Bristol, is architect.

Colo., Grand Junction—City Council has preliminary plans under way for a municipal electric light and power plant, reported to cost over $500,000, with equipment. Wood & Weber, 810 Fourteenth Street, Denver, Colo., are consulting engineers.

Ind., Anderson—The City Council is said to be planning extensions and improvements in power plant to cost about $45,000, with boiler, switchboard and other equipment.

Ind., Noblesville—The Indiana Electric Corporation, Indianapolis, has authorized extensions and improvements in power plant at Anderson, to cost over $65,000, with equipment.

Ind., Richmond—The City Council contemplates extensions and betterments in municipal electric light and power plant, reported to cost over $600,000, with equipment.

Iowa, Altoona—The Common Council plans installation of pumping machinery in connection with a proposed municipal water plant, entire project to cost about $24,500. A bond issue is being arranged.

Iowa, Davenport—The Davenport Water Co., Davenport, is disposing of a bond issue of $1,600,000, a portion of proceeds to be used for extensions and improvements in plants and system.

Iowa, Sac City—The Iowa Railway & Light Co., Cedar Rapids, Iowa, has plans for a power station at Sac City, to cost about $40,000. Company engineering department is in charge.

Ky., Bowling Green—The Kentucky-Tennessee Light & Power Co., Bowling Green, is said to be arranging resumption of construction on proposed new hydroelectric power plant on the Barren River, following temporary curtailment of work. Entire project will cost over $1,000,000, with transmission system.

Mich., Calumet—The Seneca Copper Mining Co., 11 Park Place, New York, contemplates extensions and improvements in mining properties in vicinity of Calumet, including a new electric-operated pumping station and new compressor plant.

Mich., Owosso—The Consumers Power Co., Jackson, plans extensions and improvements in lines and system at Owosso and vicinity during 1931, to cost about $325,000, including a new meter department building and other units. Company engineering department will be in charge. W. G. Cobb is district manager.

Mich., St. Ignace—The Edison Sault Electric Co., Sault Ste. Marie, Mich., has acquired the municipal electric light and power plant at St. Ignace for a consideration of $165,000, and will convert for central station service. Extensions in transmission lines are planned.

Mo., Liberal—The City Council is reported considering a municipal electric light and power station to cost about $65,000, with equipment.

Neb., North Platte—The Northwestern Public Service Co., Huron, S. D., has acquired a site at North Platte, and is projecting plans for a new steam-operated electric power plant to cost over $400,000, including transmission system. Company engineering department is in charge.

N. J., Burlington—The City Council, Burlington, plans the installation of pumping machinery and other power equipment in a new sewage disposal plant, for which a fund of about $150,000, will be arranged. B. Sleeper is city engineer, in charge.

N. Y., Endicott—The International Business Machines Corporation, Binghamton, N. Y., plans installation of electric power equipment in proposed new plant addition at Endicott, entire project to cost over $80,000.

Ohio, Athens—The City Council is reported considering a new municipal electric light and power plant to cost over $85,000, with equipment.

Okla., Oklahoma City—The City Water Department, City Hall, is said to be planning the installation of pumping equipment in the municipal filtration plant. City Engineering Department is in charge.

Pa., Avella—The Pittsburgh Terminal Coal Corporation, Wabash Building, Pittsburgh, plans the construction of a new coal-washing plant at Avella, to cost close to $350,000, with machinery. The Pittsburgh & West Virginia Railroad Co., Pittsburgh, is interested in the project.

Pa., Beaver Falls—The Armstrong Cork Co., Lancaster, Pa., plans installation of electric power equipment in connection with an expansion and improvement program at plant at Beaver Falls, estimated to cost about $100,000.

Tenn., Monterey—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in municipal waterworks to cost $100,000. Permission has been secured to issue bonds in amount noted.

Texas, Beaumont—The Coca-Cola Co., Atlanta, Ga., plans installation of electric power equipment in a proposed new soft drink manufacturing plant at Beaumont, entire project to cost over $100,000.

Texas, Refugio—The Luling Oil & Gas Co., Luling, plans installation of air compressors and other power equipment in a proposed new carbon black plant near Refugio. A gasoline plant is also proposed, entire project to cost over $100,000. Application has been made to the State Railroad Commission.

Va., Martinsville—City Council has plans under way for extensions and improvements in municipal electric light and power plant on the Smith River, including installation of additional equipment. Saville & Williamson, Electric Building, Richmond, Va., are engineers.

Va., Overall—The Page Power Co., Luray, Va., has secured permission to construct and operate a hydroelectric power plant on the South Fork of the Shenandoah River, near Overall, reported to cost over $500,000, with transmission system. Company engineering department will be in charge.